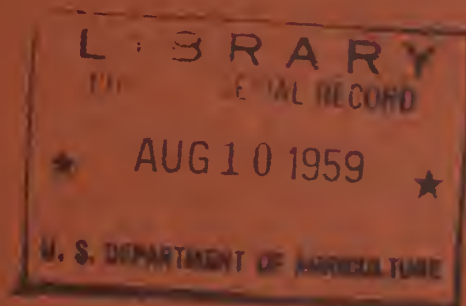


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TWENTY-SECOND ANNUAL REPORT
of
Pasture Research
in the
Northeastern United States
University Park, Pennsylvania
1958



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1958

Twenty-second Annual Report

of

Pasture Research

in the

Northeastern United States

U. S. Regional Pasture Research Laboratory
University Park, Pennsylvania
Forage and Range Research Branch
Crops Research Division,

Eastern Soil and Water Management Research Branch
Soil and Water Conservation Research Division,
and

Field Crops Insects and Bee Culture Research Branch
Entomology Research Division
of the

Agricultural Research Service
U. S. Department of Agriculture

and

The Agricultural Experiment Stations
of the
Twelve Northeastern States
Cooperating

- - - - -

Copies of this report were sent to all organizations involved in the development of the present pasture research program in the twelve Northeastern States and in addition to some institutions outside the Region where grassland research is a major interest.

For Administrative Use Only

B.

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PASTURE RESEARCH IN THE NORTHEASTERN UNITED STATES

This report, the twenty-second in the series, was prepared by and is intended primarily for use of personnel engaged in forage research in the twelve Northeastern States. It contains a brief summary of progress during 1958. Included are reports of research of project leaders at the U. S. Regional Pasture Research Laboratory, of the several forage crops technical committees, of the state experiment stations and of the Forage and Range Research Branch in Beltsville, Maryland.

The Collaborators assembled and edited materials from their respective stations, the chairmen of regional forage crops technical committees supplied copies of their annual reports, and project leaders and section heads at the Pasture Laboratory and Beltsville, respectively, prepared descriptions of their research.

The only personnel change at the Pasture Research Laboratory was the addition of Mr. Donald Burdick as part-time assistant in plant chemistry. Mr. Burdick joined us in August after completing his work for the M.S. degree at Rutgers University. He will pursue the Ph.D. degree while working at the Laboratory.

A Collaborators' Conference was held at the U. S. Regional Pasture Research Laboratory on September 4 and 5, 1958. Research at this station was reviewed and the Collaborator from each state reported on forage research at his Experiment Station. An evaluation committee of the Collaborators was appointed to make recommendations concerning future activity of the U. S. Regional Pasture Research Laboratory. This committee noted that an entomologist has been added to the staff and that increases in the budget and technician staff have been made. The committee stressed the need for increased cooperation between appropriate investigators from the Laboratory and the states. The desirability for more travel in the Region by our personnel was again noted. The committee suggested that the functions and responsibilities of the Collaborators be reviewed and clarified. The full report follows:

REPORT OF REGIONAL EVALUATION COMMITTEE

General Recommendations

1. The Pasture Laboratory should concentrate its efforts on basic research on factors affecting the improvement and utilization of forage plants.
2. It is important that the Laboratory serve as a source of improved techniques in forage plant research.
3. In the future, other fields, such as microbiology, nematology, weed control physiology, plant anatomy and morphology, merit consideration.
4. It is suggested that at least one, preferably two, full-time research assistants or technicians be made available to each project leader as a means of increasing his effectiveness.

2.

5. Provision should also be made for adequate equipment and facilities. Enough funds should be provided for travel to enable project leaders to cooperate effectively with work under way at Northeastern Experiment Stations in order to encourage cooperative research and exchange of research ideas and results.

Specific Recommendations

A number of suggested problems for research in forages are listed below under the major research fields. It is realized that the solution of most of these problems will involve the combined efforts of specialists in two or more fields. Responsibility for work to be accomplished will of necessity be assumed by personnel in the respective fields. Items of major priority are listed as follows:

Agronomy. To study:

1. Relationship of climatic factors (particularly microclimate) to (a) persistence and growth and (b) incidence of insect and disease pests.
2. Effect of management variations on competition between all species present.
3. Life history (including root) studies of the factors affecting seedling establishment, maturity and longevity.

Soils. To study relationship of the following factors to forage production:

1. Soil moisture and temperature.
2. Soil nutrient status and nutrient uptake from native and applied nutrients.
3. Soil micro-organisms, particularly legume bacteria.

Plant Chemistry.

1. Continued study of the chemistry of cell walls and carbohydrates.
2. The development of rapid and accurate methods of screening plant populations for acceptability, quality and nutritive value. Cooperative research with animal nutrition specialists at appropriate stations will be necessary for the accomplishment of the last problem.

Breeding, Genetics and Cytogenetics.

1. Study the effectiveness of techniques of breeding.
2. Isolation and creation of new sources of hereditary variation suitable for use by plant breeders.
3. Continue genetic and cytogenetic studies.

Pathology.

1. Identification of causal organisms of specific diseases and the determination of their life history.
2. Nature of resistance to specific diseases.
3. Development of methods of producing artificial epiphytotics.
4. Study the physiology of fungi, particularly toxin and pigment production.
5. Estimation of importance of specific diseases. (not of high priority)

Entomology.

1. Identification of insect pests which produce deleterious effects on the major forage plants and the determination of their life history.
2. Nature of resistance to specific pests and the development of methods of producing artificial infestations.
3. Studies of the mode of action of insect pests on the host plant.
4. Estimation of importance of specific pests. (not of high priority)

Additional Problems Needing Attention

1. Basic studies of carbohydrate breakdown by micro-organisms in relation to availability of feed nutrients.
2. Nodulation studies with Rhizobia.
3. Secondary infections in close relation to pathological problems.
4. Study of growth patterns as influenced by environment, management and nutrition levels. These would presumably have pronounced effects upon animal acceptance, feed quality, and insect and disease relationships.

RESEARCH AT THE PASTURE LABORATORY

GENETICS, ENTOMOLOGY AND PATHOLOGYAlfalfa

Selection for Disease Resistance

In September 116 surviving plants from a polycross progeny test seeded in 1951 at Storrs, Connecticut were selected. From 3 to 10 of the more desirable survivors from each of 16 progenies were selected. During the winter of 1958-1959, 58 crosses were made among these plants i.e. each plant was crossed with one other plant. This material is available as a source of possible resistance to crown rots since loss of stands in the test was attributed to crown rots and bacterial wilt.

The program to develop strains, and possibly a cultivar, of alfalfa with resistance to foliar pathogens is being continued (1957 Annual Report, page 2). Seeds harvested from plants that were crossed and selfed during the winter of 1957-1958 were germinated and space planted in flats in early spring 1958. The resulting seedlings (approximately 12,000) were screened for resistance to Pseudopeziza medicaginis and Ascochyta imperfecta. In addition many seedlings were eliminated on the basis of lack of vigor, poor color, and other abnormalities. Before they were transplanted to the field, bacterial wilt inoculum was poured over the cut roots of the seedlings (over 5,000 seedlings).

During the growing season Ascochyta was moderately severe and Pseudopeziza and Pseudoplea were present in epidemic proportions. The cool moist summer was especially favorable for the latter disease.

In fall 1958, after two individual plant ratings, 310 plants were brought into the greenhouse. Selection was based upon disease resistance, vigor, color, etc. The plants again were inoculated with Pseudopeziza and Ascochyta. In the inoculation chamber Rhizoctonia attacked many of the plants resulting in the killing of the young shoots. On the basis of resistance to the above diseases and general plant desirability, the number of plants was reduced to 120.

No more backcrosses will be made. The genes for resistance will be concentrated by inbreeding and intercrossing. In fall 1959 selected plants will be increased vegetatively in hopes of sending them West for seed production. Seed from these plants will be used to test the efficiency of techniques developed in this program and the efficiency of the backcross method in adding disease resistance to susceptible but otherwise desirable material.

Evaluating for Resistance to Insects

In the fall 1958 seedlings of Buffalo (susceptible) and A-600 (resistant) were started in the greenhouse on several dates. It was planned to screen these seedlings for reaction to leafhoppers and to develop techniques suitable for screening large numbers of seedlings. Difficulty was encountered in building up sufficient numbers of leafhoppers to screen the seedlings. Low light intensity during the winter months at this location may have been a contributing factor.

Plants of Buffalo and A-600 somewhat beyond the seedling stage have been exposed to leafhoppers and rated for yellowing and shortening of the internodes. In these greenhouse tests to date the two varieties do not appear strikingly different in reaction and no plants with outstanding resistance have been found.

In order to ascertain whether the genetic factors in Moapa alfalfa parent clones that give resistance to the spotted aphids have an effect on leafhoppers, Moapa clones were compared with plants of the variety, African. Yellowing of the two groups of plants in the field due to leafhoppers was not different; both were highly susceptible. Leafhopper counts taken on one date suggested that nymphal populations were consistently higher on African. In general, however, it is safe to conclude that the factors operating to give resistance to the spotted aphid do not operate against the potato leafhopper.

Root-spreading alfalfa selections were examined for plant resistance to spittlebugs by counting the nymphs per mass and the number of masses per plant. Number of spittle masses and nymphs varied widely on different plants. Incidence of this insect on replicated clonal plantings will be noted to ascertain whether heritable variations in resistance exist.

Twenty-six clones differing widely in reaction to the potato leafhopper were rated for reaction in 1957 and 1958. The inter-annual correlation was 0.87.

Survey for Alfalfa Weevil in Pennsylvania

The alfalfa weevil was found in the Pennsylvania counties of Clinton and Fayette for the first time this year. Populations increased in Centre County fields that were first found to be infested in 1957, and this season a few larvae and adults occurred in the University and Pasture Laboratory fields.

Combining Ability in Alfalfa Single Crosses

A test including the 91 possible single crosses among 14 clones of alfalfa was seeded in broadcast plots in 6 replicates in the spring 1958. Seedling vigor data were taken in August following clipping for weed control. Analysis of these data for general and specific combining ability indicates that variances for both types of combining ability are significant but that the variance for general combining ability is 7.8 times that for specific combining ability. This indicates that genes with additive effects are of primary importance in controlling seedling vigor in the present material, though the significant variance for specific combining ability also indicated that dominant and/or epistatic genes were also operating to condition seedling vigor.

The same 91 single crosses were seeded in rows by other workers at Lafayette, Indiana and Lincoln, Nebraska and seedling vigor data were taken on the initial seedling growth. Correlations of seedling vigor data between locations were: Pennsylvania vs. Indiana +0.90, Pennsylvania vs. Nebraska +0.92, and Indiana vs. Nebraska +0.86.

These data indicate that seedling vigor is a highly heritable character and that breeders may place confidence in observation made at distant locations.

Varietal Hybrids and Mixtures

Ten alfalfa varieties, 15 varietal hybrids and 11 mixtures of 2 varieties each were seeded in 6 replications in 1958 and excellent stands obtained. The varietal "hybrids" consist theoretically of 50 percent hybrid seed, 25 percent of seed of variety A and 25 percent of variety B.

Design of the experiment permits measurement of possible heterosis from varietal hybrids. It also permits partitioning of possible heterotic effects from any beneficial effects resulting from growing a mixture of genotypes as represented in several pairs of varieties. Similar tests in several additional states outside the Region will permit a broad analysis of the potentialities of varietal hybrids.

Inbreeding Alfalfa

Previous work at this location had indicated an average reduction in forage yield from $S_0 = 100$ to $S_1 = \text{ca. } 68$ percent. A number of S_1 plants, however, appeared to be as vigorous as their S_0 parent. A clonal test established in 1957 involving 12 pairs of S_0 and selected vigorous S_1 plants was harvested in 1958. In the first harvest year, 2 S_1 clones yielded significantly more than their S_0 parents, 5 S_0 parents were superior to their S_1 's and in 5 comparisons S_1 and S_0 were not significantly different.

Breeding Adapted Root-spreading Alfalfas

Background information on this work was presented in the 1957 Annual Report, page 4. Analysis of root-spreading data on 60 clones in both cultivated plots and in plots overseeded with timothy has been completed. The results indicate that root-spreading was expressed equally in both types of plots and that the interaction, clones x cultural methods was not significant. This suggests that the overseeded nursery may be used in evaluating root-spreading materials with considerable saving of manpower.

Three of the superior clones (56-128, 56-140 and 56-151) were intercrossed in all possible combinations and 100 seeds of each cross forwarded to Utah for production of Syn. 2 seed. This seed may be used to advantage in evaluating the material on certain sites and with management treatments to bring about desired expression of the root-spreading character. This seed may also be used to establish second-cycle breeding nurseries in the Northeast.

Intercrosses among the superior recovering root-spreading clones will be established in a new nursery in 1959.

Cutting Frequencies on Rhizomatous and Upright Alfalfa

This experiment (1957 Annual Report, page 3) was discontinued in 1958 except for taking stand counts. The combined analysis of yield data taken from 1954 through 1957 has been completed. A number of conclusions may be drawn from the data, i.e.

1. One cannot accurately predict that a given morphologic type, i.e. rhizomatous or upright, will perform relatively better under more frequent defoliation than other types.
2. In general, polycrosses of clones with high combining ability were high yielding under both cutting treatments while progenies of clones with low combining ability were inferior under both cutting treatments.
3. A significant interaction between years and cutting periods (first harvest vs. yield for remainder of the year) is largely due to year to year variation in climate for the two growth periods.
4. A significant years x strains x management interaction was due to the fact that the strains x management interaction was not consistent from year to year.

Inheritance of Qualitative Traits

The inheritance of albino and yellow seedlings is being studied because such traits may be of interest to seed certification in addition to the genetic information they may provide.

A normally non-flowering, dwarf alfalfa clone was induced to flower by 3 repeated applications of 0.1 mg. gibberellic acid at 3-week intervals. Hybrid progeny resulting from crossing to a normal clone will be carried into segregating generations through backcrossing and selfing.

Two partially male-sterile (75 percent aborted pollen) plants were identified, selfed and crossed to permit future determination of the genetic nature of this characteristic.

Cytogenetics and Crossing Relationships Among Alfalfa Clones

The 14 parent clones of the 91 single crosses that are being evaluated for combining ability will be tested for self-fertility as measured by chromosome behavior in meiosis, pod set, seed set and position of seed in pod in relationship to seedling vigor of selfed and outcrossed progeny.

Ladino and Other Clovers

Karyology, Cytogenetics and Interspecific Hybridization in Clover

The chromosome numbers of 16 clover species were determined as follows:
 $2n = 14$: T. dubium, Aberystwyth, T. procumbens F.C. 32,228, *T. radiosum P.I. 206,771, *T. striatum F.C. 32,203; $2n = 16$: T. fragiferum F.C. 24,315, *T. isthmocarpum P.I. 203,664, *T. lappaceum P.I. 200,371, 206,764, T. michelianum F.C. 24,961, T. pallidum P.I. 201,213, T. resupinatum P.I. 163,314, P.I. 164,356, *T. scutatum P.I. 202,808, *T. semipilosum P.I. 226,287, P.I. 246,354, *T. subrotundum P.I. 196,895, T. variegatum F.C. 24,533; $2n = 32$: T. ambiguum P.I. 106,699, *T. willdenovii F.C. 30,109.

*Not reported previously in the literature.

Although clover chromosomes are small and generally undistinguishable some improvement was made in the spreading and staining of chromosomes from smeared cell of actively dividing root tips. Further study may determine which of the employed steps caused this improvement: (1) Pretreatment in

paradichlorobenzene for 2 hours at room temperature, (2) transfer to tap water for 8 hours at +5° C., and (3) fixation in aceto-orcein.

Based on the literature and notes on morphological characters recorded for 30 clover species, interspecific crosses were attempted in the greenhouse among these 12: T. ambiguum, T. dubium, T. fragiferum, T. hybridum, T. isthmocarpum, T. michelianum, T. nigrescens, T. pratense, T. repens, T. resupinatum, T. tomentosum and T. willdenovii.

Approximately 10 to 15 days after pollination the florets were removed and examined for developing pods and stimulated ovules. Of 2,615 florets examined so far, ovule stimulation was noted in 10. Excision of embryos was performed under aseptic conditions and the remaining viable embryos are being grown to determine whether they are hybrids. Prior to initiation of this work, research on suitable techniques for artificial rearing of clover embryos was carried out, and the chosen method had been employed successfully for several clover species.

In view of the strong barriers of interspecific incompatibility in the genus, which has been demonstrated here and elsewhere, it seems logical to seek information about fertility relationships of a limited number of self-incompatible diploid species, their induced tetraploid derivatives and interspecific hybrids at the tetraploid or higher polyploid level.

Inheritance of Leaf Markings

From F₂ and testcrosses it has been found that the red-V leaf marking in white clover is conditioned by a single factor dominant to no marking. Because all plants with the red-V also had the white-V marking crosses were continued in 1958 to study linkage relationship between these two traits. It is hoped that with the information obtained from these crosses the material can be prepared for publication in 1959.

Colchicine and Somatic Mutation

Because reports in the literature have claimed that treatment with colchicine has caused permanent changes in sorghum and flax, the possibility of obtaining such somatic mutation in Ladion clover was investigated. Colchicine at 4 concentrations (0.05, 0.1, 0.2, and 0.4 percent) in aqueous solution with 10 percent glycerol in addition to a check treatment without colchicine were applied to a selection that was heterozygous for the red-V leaf marking character. A randomized complete block design was used with 4 replicates, each with 3 plants in 6-inch pots. Eight shoots per plant were treated and labelled in the greenhouse on March 18, giving a total of 96 shoots per

treatment. On May 21, the plants were transplanted to the field on 3-foot centers for the purpose of making morphological observations. No morphological changes were noted on the treated shoots during the growing season of 1958, and the experiment was discontinued. Before drawing conclusions an attempt will be made to repeat the experiment with alfalfa in 1959.

Attempts to Increase Persistence in Ladino Clover

"Winter injury" in the 1956 source nursery (1957 Annual Report, page 7) was severe. The nursery was clipped during the season and 18 of the better plants were selected in the fall. These are being intercrossed to provide material for a new cycle of selection.

There were few surviving plants in the polycross progeny test seeded with orchardgrass and with brome grass three years previously. It had been planned to make selections among the survivors in the fall of 1958. Establishment of new seedlings occurred so extensively in 1958 on the test area that these plans were cancelled.

Factors Affecting Persistence of Ladino White Clover

The field experiment set up in April 1956 to determine some of the factors and interactions involved in stand depletion of Ladino white clover (with orchardgrass) is being continued (1957 Annual Report, page 8). Ladino clover has been maintained at a high level only in the one plot series that was fumigated (before seeding), sprayed with insecticides and fungicides, and clipped frequently. In the late-cut treatment, stands were reduced somewhat in the sprayed plots and greatly depleted in the other plots.

A large number of volunteer seedlings became established in the frequently cut and late cut plots. The few seedlings that emerged in the plots where the flower heads were removed weekly were pulled when counted. The effect of natural reseeding should be striking in 1959.

Soil samples (4 inches deep) were taken from sprayed and unsprayed plots and examined for root feeding larvae. In the unsprayed plot, 52 larvae of Calomycterus setarius and 16 larvae of Sitona hispidula were found in the examination of one square foot. No larvae were found in the soil of sprayed plots.

The high persistence of Ladino white clover in the sprayed plots was attributed to the control of insects, the control of unknown diseases, or the addition of minor elements or other substances in the above chemical sprays.

Observations on the plots will be continued in 1959.

Survey of Insects on Ladino Clover

A periodic survey of Ladino white clover showed the most abundant insects to be seed weevils, tarnished plant bugs, pea aphids, meadow spittlebugs, six-spotted leafhoppers and potato leafhoppers. The most abundant soil insects were clover root curculios and Calomycterus setarius.

Ladino Clover Insects - Pathogen Relationships

A number of the Ladino white clover insects were examined for possible vectors of disease incitants. Fusarium was found in 13 different genera. Overwintering clover leaf weevil larvae contained several organisms within their bodies including four plant pathogens Pseudoplea, Colletotrichum, Fusarium and Phoma, suggesting that this weevil may aid in the overwintering of these fungi in clover.

Red Clover

Insect - Pathogen Relationships

A study was made to determine the relationship of root-feeding insects and Fusarium to the length of red clover stands. Insect- and disease-free plants with the equivalent of one year's growth because they were started in the greenhouse were space-planted in field plots in May 1957. Controlling clover root curculios and borers with insecticides and reducing root rots by fumigating the soil did not prolong the life of plants over untreated plants.

Another experiment using potted red clover plants with caged clover root curculios, borers, and mechanical injury (cutting roots) and adding Fusarium in the greenhouse showed that these factors produced growth differences and indicated an injury - root rot association.

A study made on the life history of first year red clover and its roots in the field from July to December showed that curculio injury increased from July to October. Rot or discoloration was associated with about one-third of the feeding areas. Organisms isolated were mostly Fusarium spp. and Rhizoctonia solani. An internal breakdown condition of unknown cause occurred in about one-fourth of the plants.

Clover root borers spend much of their lives within red clover crown and roots, but adults have a flight each spring which permits them to infest new fields. In 1957 the flight period occurred April 26 to June 6 with greatest activity occurring May 8 to 16. In 1958 flights took place May 2 to July 2 with greatest activity occurring May 13 to 28. Eleven percent of the borers captured in the 1958 flights carried Fusarium on their bodies.

Thirteen varieties and selections of second-year red clover plants from the persistence plots were examined for borers in the fall 1958. Eighty-three percent of these plants were infested and average borer populations per plant ranged from 1.73 in Dollard to 7.15 in Louisiana #1.

Internal Discoloration of Crown Tissue in Red Clover

In the examination of red clover seedlings and older plants, two types of internal discoloration have been observed in the crowns (and sometimes roots). Usually no fungus can be isolated from these areas. Fungi rarely isolated include Fusarium spp. and various saprophytes.

One discoloration occurs in the pith tissue in the crown - called Internal Breakdown (IB). The necrosis can seldom be traced to the bark. The other discoloration occurs in the cambium zone (exact area not yet determined). A majority of plants showing this condition (C.D.) also exhibit virus symptoms.

The aim was to determine the causes of IB and CD and factors affecting their prevalence in the greenhouse.

Materials were as follows: 1,100 seedlings of red clover, soil - greenhouse potting mixture (except where noted), daylength 16 hours (except where noted), temperature 65-70° F. Treatments - 75 pots for each treatment, September 1958: (1) control - no treatment, (2) control - add 2x nutrient solution each week, (3) virus inoculated, (4) virus inoculated, (5) low temperature (55°-60°), (6) short day (no artificial lights), (7) shade (cheesecloth) and under misting system, (8) field soil (where IB and CD occur), (9) field soil plus boron, (10) field soil plus minor elements, (11) soil low in K, (12) soil low in K but K added, (13) add dilute acid (to learn if CD occurs when a plant is dying from any cause), and (14) add sugar to cause plasmolysis (same reason as No. 13).

The plan was as follows: Dig and examine 5 plants at one month intervals beginning November 1958. Take notes on root diameter, presence of IB and CD, size of IB area, amount of root and crown rot, and miscellaneous observations.

Considering all treatments, the percentage of IB increased from 24 percent in December to 48 percent in February. No treatment greatly increased or eliminated the condition. The lowest percentage was in plants grown in field soil to which minor elements had been added at regular intervals. The field soil was taken from an area where plants showed the IB condition.

The other internal discoloration, cambium discoloration (CD), was evident in only a few plants. Four plants that were infested with a necrotic streak-type virus (that finally killed the plants) showed the CD. Also some plants to which acid had been added to the soil showed the condition. These plants were usually stunted and showed some leaf burning. It is possible the CD may occur when the plant is dying from any condition, and is the result rather than the direct cause.

The test will be continued and expanded in 1959.

The Pseudoplea Diseases of Legumes

The study concerning Pseudoplea has been expanded and is now a cooperative project involving two other researchers who have worked with the fungus. Dr. E. S. Luttrell, Georgia Experiment Station, has done considerable work on the morphology of Pseudoplea species and is writing a section on that phase. Dr. L. W. Baxter, Jr., while at Clemson, South Carolina (South Carolina Agr. Expt. Station), conducted some physiological studies which he is now writing up for the paper. While work at the Pasture Laboratory covered part of the above studies, pathogenicity and host range studies have been emphasized. By pooling our data it is believed that a valuable monograph can be written which will carry more weight in clearing-up some of the controversies now in the literature.

Pathology and Morphology of Some Leguminous and Related Species of Stemphylium

The host range and morphology of 8 named species and 4 unidentified forms of Stemphylium obtained from various hosts and locations were investigated. The unnamed conidial types were different in certain morphological or cultural characteristics as well as in pathogenicity from similar named species of Stemphylium and are proposed as possible new forms or species.

Six-week-old plants of alfalfa, red clover, Ladino clover, birdsfoot trefoil, blue lupine, crown vetch, and tomato were inoculated in the greenhouse. Stemphylium botryosum had the widest host range of the species tested, being pathogenic on all test plants except tomato and birdsfoot trefoil. Unidentified isolates (small, slightly spiny conidial types) from crown vetch and Ladino clover somewhat similar to S. botryosum were practically non-pathogenic on any of the test plants. S. sarcinaeforme from red clover and Ladino clover attacked both hosts but symptoms were more severe on red clover. An isolate from white sweet clover attacked sweet clover, red clover, and alfalfa, but not Ladino clover. Three isolates of S. loti from birdsfoot trefoil collected in 3 states were pathogenic on birdsfoot trefoil and blue lupine. There were marked differences in pathogenicity and host range within species, particularly with isolates of S. botryosum and S. solani, possibly due to pathogenic specialization. S. botryosum is reported for the first time as a pathogen of crown vetch and S. loti as a pathogen of blue lupine. The small-spored isolate from crown vetch produced perithecia and ascospores somewhat similar to Pleospora herbarum in culture, suggesting that the fungus is closely related to S. botryosum. The other species did not produce an ascigerous stage.

Orchardgrass

Breeding Improved Dactylis glomerata

Approximately 4,000 plants representing 19 sources of late maturing orchardgrass were established in a source nursery with spacings of one foot between plants. This close spacing was considered advantageous in obtaining a more realistic evaluation of plants with between-plant competition. Vigor of these plants in early fall 1958 was recorded. Agronomic and disease notes will be taken in 1959 preliminary to making selections.

Completely male-sterile plants with better than average (for this population) agronomic qualities are being crossed with some of our better fertile clones in hopes of introducing male-sterility into agronomically desirable material for future use in testing materials for combining ability and possible development of F_1 hybrids.

Yields were again taken on the polycross progeny test seeded in 1956 along with Potomac, S-37 and P.L. Syn. "R", selected for resistance to leaf diseases. Yields of the earlier maturing entries such as Potomac, MIX-11 and MX-7 were significantly higher at the first harvest but differences among entries in yield at the second and third cuts were not significant. Significant differences among entries for reaction to "streak" were noted on July 21, 1958. P.L. Syn. "R" and Potomac had readings of 3.2 and 5.7 respectively, while the high yielding MIX-11 had 9.5. In general, the later maturing strains had less streak than the earlier ones.

Male Sterility in Orchardgrass

Male-sterile Dactylis glomerata observed in the greenhouse in 1957-1958 for percentage pollen abortion was classified in the field for agronomic desirability and additional observations of pollen abortion were recorded for plants that had not headed in the greenhouse. Some of the most desirable completely male-sterile clones were brought into the greenhouse for crossing with agronomically desirable and disease resistant clones during winter 1958-1959.

Study of meiosis of male-sterile Dactylis glomerata material was continued with plants that flowered in the greenhouse. Percent stainable pollen of the fertile clones ranged from 10 to 94, with an average of 67.5 for 20 clones. Most of the 33 clones classified as male-sterile had 7 percent or less stainable pollen, 18 of them having no stainable pollen. The further the study has been pursued, the more difficult it appears to arrive at reliable chromosome number determinations. Aneuploidy, however, is undoubtedly characteristic of this material, appearing in both the fertile and the male-sterile clones, and possibly differentially in root tip and meiotic cells. The challenge presented by this investigation requires continued efforts to meet it. Awaiting further determination of pollen stainability is a population of seedlings that arose from crosses between the male-sterile clones and a number of agronomically desirable orchardgrass clones. The problem still remains: to discover how male-sterility in orchardgrass is determined and incidentally to find whether the aneuploidy is of the nature of B-chromosomes reported for other grasses and whether it is concerned with the male-sterility.

Of 15 completely male-sterile plants examined in detail at AI of meiosis, 13 possessed 30 chromosomes while two had 28 chromosomes. This would seem to implicate aneuploidy as a contributing factor in male-sterility. The 2 male-sterile plants with the normal number of chromosomes on such an assumption, however, would have to contain unbalanced complements. It still remains possible that one set of homologous chromosomes carries genes for male-sterility and that only plants with a certain number of male-sterile genes (i.e. via extra chromosomes) are male-sterile.

BromegrassResistance of Bromus inermis to Helminthosporium bromi (Brown Spot)

Open pollinated seedlings from 7 inbred clones and 6 non-inbred clones previously selected for resistance to Helminthosporium bromi and Rhynchosporium secalis, scald were screened for resistance to H. bromi.

Methods were devised for producing abundant conidia in culture and for producing the disease in epidemic proportions. No record of such methods has been found in the literature. The procedure is as follows:

1. Make 50 or more isolations onto V-8 juice agar.
2. Make transfers from isolates that produce most conidia. Keep cultures in laboratory at temperatures below 22° C.
3. Make repeated transfers (sub-cultures) from sporulating saltants and areas of mass sporulation. Always transfer conidia and not mycelium alone.
4. For inoculations, prepare 2 plates for each flat of seedlings.
5. Make water suspension of spores scraped from surface of agar. Within a week another "crop" of conidia can be harvested from the same cultures. The same plates can be stored in a refrigerator for 3 months for asco-spore production.
6. Fifty-five seedlings are transplanted to each flat of soil (Five of the seedlings are a susceptible cultivar, Manchar).
7. Seedlings approximately 3 months old for best inoculation.
8. The inoculation chamber is described elsewhere in the report (Technique Section).
9. A detergent (e.g. 1 drop of Tween 80 per quart of inoculum) is put in the spore suspension and sprayed onto the seedlings. Apply twice, once in A.M. and again in P.M. Keep air temperature between 21°-25° C. at 100 percent relative humidity for 2 days.
10. Transfer to greenhouse bench, 68°-75° F.
11. After 8-10 days take disease notes. Pull susceptible plants and reinoculate.
12. Transfer resistant seedlings to pots.

The above method was used in screening smooth bromegrass seedlings in 1958. Eighteen hundred seedlings were reduced to 366 on the basis of resistance to H. bromi (very weak seedlings were also discarded).

The resistant seedlings will be screened for resistance to another fungus (Stagonospora bromi) and then transplanted to the field for further observations and a new cycle of selection.

Stagonospora bromi on Bromus inermis

Stagonospora bromi was isolated from brown lesions on leaves of smooth brome-grass in Pasture Laboratory plots. The disease has been reported to be of importance only in sections of the Midwest and West. Probing experiments are planned to determine its prevalence and importance. Very little work has been done on the fungus.

Cytogenetics of Bromus inermis

Progenies obtained by crossing a normal B. inermis clone with an unexpected $2n = 56$ clone that originated from a $2n = 28 \times 2n = 56$ cross were examined cytologically. Particular attention was given to frequency of micronuclei in quartets and pollen stainability. Previous study of meiosis of $2n = 42$ brome-grass obtained from crossing the 28 and 56 chromosome forms had suggested either: (1) That the meiotic disturbances in $2n = 42$ were due to a genomic relationship like AAA_1BBB_1 in which case A_1 and B_1 were contributed by the 28-chromosome parent, or (2) due to plain triploidy for two genomes as $AAABBB$.

Under assumption (1) above, the unexpected octoploid would be $AAA_1A_1 BBB_1B_1$ and when crossed to normal B. inermis would give $AAAA_1 BBBB_1$ with expectations of greater than normal meiotic disturbances. Under assumption (2), on the other hand, the unexpected octoploid would be $AAAABBBB$ and would be expected to give progenies, in crosses with normal B. inermis, with meiosis typical of the species.

Results of the present investigation support assumption (2) and in turn support the theory that this species is autotetraploid for two basic genomes.

Tall Meadow Fescue

Meiosis and Genome Homologies in Tall Fescue

The purpose of this study was discussed in the 1957 Annual Report, page 11. S_1 plants of a tall fescue clone exhibiting AI bridges were established in 1958 and brought into the greenhouse for analyzing sporocyte samples for frequencies of AI bridges. Cytological collections are fairly complete and these will be studied in 1959.

Selection for Fertility in Derivatives
of Intergeneric Hybrids

Progenies with 14, 21, and 28 chromosomes have been derived from the triploid hybrid, Lolium perenne x autotetraploid Festuca elatior. Difficulty has been encountered in getting this material to head in the greenhouse. Therefore, field plantings were established in 1958 from which "seed" will be harvested in 1959.

Of some interest are some golden-stripe Festuca elatior-like diploid derivatives. Selfs and crosses will be made in 1959 preliminary to genetic analysis of this character.

Vigorous triploid progenies of the original triploid intergeneric hybrids were cloned and interplanted. Some of these appear to produce some viable pollen and selection for seed fertility among possible progenies will continue.

Plants with 28 chromosomes, possibly amphidiploids, were also planted to obtain seed if any. These plants are quite vigorous and have floral morphology more nearly like L. perenne.

A few plants arising from colchicine treated clones of (L. perenne x 4X Festuca elatior) x F. arundinacea were established in 1958. Chromosome number determinations on these plants have not been made but fertility will be checked in 1959.

Forty-two-chromosome plants of two types have been derived from the chromosome-doubled triploid intergeneric hybrids. One type, without ciliated auricle, was derived by open pollination of 42-chromosome colchicine doubled triploid hybrids. These are less vigorous than the triploids, highly sterile and meiotically irregular. The other 42-chromosome plants resulted from pollination of the colchicine doubled triploid, i.e. $2n = 42$ with pollen from F. arundinacea. These plants have ciliated auricles, are quite vigorous and represent an improvement in palatability over tall fescue. Plants of this type were cloned and interplanted with tall fescue clones. Seed from the hybrid plants will be harvested in 1959 if they backcross to tall fescue. As soon as some male-fertility is attained the hybrid derivatives will be intercrossed in attempts to obtain vigorous, palatable and fertile selections.

Analysis of the cytological behavior of L. multiflorum x F. arundinacea hybrids and derivatives developed by R. C. Buckner is nearing completion. Results are in substantial agreement with those reported last year (1957 Annual Report, page 11).

Palatability of Intergeneric Hybrids

It has been indicated (1955 Annual Report, pages 6-8, 1956 Annual Report, page 9) that Lolium perenne was crossed with autotetraploid Festuca elatior to produce triploid hybrids. Chromosome number of these hybrids was doubled to $2n = 42$, the same as that of tall fescue, Festuca arundinacea. A few hexaploid progenies, without hairs on the auricles, were obtained and are presumed to have resulted from intercrossing among the relatively sterile hexaploid hybrids. Other hexaploid progenies, with hairs on auricles, resulted from pollination of the hexaploid hybrids by Festuca arundinacea. The object in making the latter cross was to introduce palatability factors from L. perenne and F. elatior into F. arundinacea and retain the vigor of the latter.

Data obtained by Dr. R. C. Buckner at Lexington, Kentucky in 1958 on some of these plants indicate:

1. A high degree of vigor and excellent palatability for the triploids.
2. Considerable variation in both vigor and animal acceptance among 42-chromosome hybrids. In general, the hexaploid plants without cilia are much reduced in vigor as compared with the triploid progenitors and with the plants with cilia resulting from hybridization with tall fescue.
3. Certain of the hybrids represent a long step forward in palatability in contrast to Kentucky 31 tall fescue.

These grazing data lend encouragement to the promise of combining the desirable features of the three parent species. The challenge to overcome hybrid sterility still exists however.

BIOCHEMISTRY, PHYSIOLOGY AND SOILS

Carbohydrate Studies on Grasses

(In cooperation with the New Hampshire Station)

Studies on the carbohydrates of grasses have been underway for some years in cooperation with the New Hampshire Station. At present, emphasis is being placed on hemicellulose (1957 Annual Report, page 14).

Hemicelluloses occur as mixtures which on hydrolysis yield 5 sugars and an undetermined number of uronic acids. It is not known whether a single hemicellulose is a polymer of a single sugar or of more than one component. The order and rate of release of these components are being studied for the purpose of giving some information on their arrangement in the hemicellulose molecule. As losses occur during the preparation of the hemicelluloses, their hydrolysis is being carried out while they are still attached to the holocellulose.

Chlorite holocellulose (1955 Annual Report, page 16) was subjected a number of times in succession to treatments with dilute acid at the temperature of boiling water to yield three main products, free sugars, some soluble hemicelluloses, and the unattacked residue. In minor quantities were also found uronic acids, biuronides, and oligosaccharides. After each acid treatment the free sugars were determined quantitatively after chromatographic separation. The soluble hemicelluloses were separated from the free sugars by precipitation in alcohol and then the hydrolysis was completed. Finally the insoluble residue was analyzed to determine the components of the hemicellulose still attached to it.

An example of such study is given in Table 1. Four successive extractions with boiling 0.01 N HCl were carried out, in this case for 1, 2, 4, and 16 hours, respectively. Analyses were made of each filtrate. Arabinose was the sugar most readily and completely removed from the holocellulose. Over 95 percent of the total arabinose was removed by these four treatments with very dilute acid, 57 percent as a free sugar and 38 percent as hemicellulose which required further hydrolysis. Even in the first extraction lasting only 1 hour, 41 mgs., or 22 percent of it was set free. Xylose was the most abundant sugar, amounting to about two-thirds of all sugars reported. It was also the most resistant to hydrolysis, only 62 percent being released altogether and only a fraction of that in the free form, most occurring in the filtrate as hemicellulose which required additional hydrolysis. Two other sugars showed intermediate rates of release under like conditions. Very little glucose was found in the free state. Although complete recovery of any of the sugars was not obtained by analysis of the extracts, xylose alone remained attached to the cellulosic residue

Table 1. Release of sugars and hemicellulose by acid treatment of holocellulose. Four grams of orchardgrass holocellulose were heated four times successively with 0.01 N HCl, for 1, 2, 4 and 16 hours respectively.

		<u>Galactose</u>	<u>Glucose</u>	<u>Arabinose</u>	<u>Xylose</u>
Content in holocellulose,	mgs.	68.0	184.0	184.0	780.0
Removed in 1st extraction					
Free sugars,	mgs.	1.2	---	41.2	3.2
Hemicellulose,	mgs.	13.4	43.4	24.3	96.9
Removed in 2nd extraction					
Free sugars,	mgs.	3.1	---	47.2	7.8
Hemicellulose,	mgs.	27.6	62.0	42.6	203.1
Removed in 3rd extraction					
Free sugars,	mgs.	1.7	---	11.6	16.0
Hemicellulose,	mgs.	3.7	31.3	4.2	94.1
Removed in 4th extraction					
Free sugars,	mgs.	1.7	1.8	5.4	55.4
Hemicellulose,	mgs.	---	11.9	---	13.7
Total of 4 extractions, in percent of total found in holocellulose					
Free sugars,	%	11.3	1.0	57.2	10.6
Hemicellulose,	%	65.7	80.8	38.6	52.3
Total removed	%	77.0	81.8	95.8	62.9

if the extractions were carried out a sufficient number of times. As the total quantity of each sugar was accounted for, losses must occur. Future work will be directed toward measuring and controlling these losses.

In addition to the above sugars, another, rhamnose occurs in the extracts, and also biuronides and oligosaccharides. The last two appear as minor spots on chromatograms which had to be removed, further hydrolyzed, and again chromatographed to reveal the identity of their components. Many were found to be of mixed composition, containing two kinds of sugar or a sugar and a uronic acid.

In general, the data support the general view that a major constituent of hemicellulose of grasses consists of a central core of repeating xylose units of great length. Some branching is known to exist in hemicelluloses in general and other sugar and uronic acid polymers occur. It is probable that hemicelluloses occur which consist of only one type of component but the presence in the hydrolyzates of oligosaccharides containing two different kinds of sugars indicates that hemicelluloses of mixed composition also exist.

Measurement of Nutritive Value of Pasture Plants

It is the object of this research to uncover information that would allow the chemist or agronomist to evaluate forages by chemical analysis or other laboratory technique. Forages of known digestibility have been supplied by the Pennsylvania, Delaware, Massachusetts, Maryland, New Hampshire, New Jersey, and Missouri stations, some with the aid of the N.E. 24 Technical Committee. Analyses are being made of these samples and the results studied in relation to digestibility data.

The determination of lignin in forages is carried out for the purpose of predicting the digestibility of forages, low lignin being associated with high digestibility, and vice versa. Effort was directed during the past year in developing a more rapid and more reliable method for determining the percentage of lignin. Methods in common use were studied and each step examined in order to determine whether it could be simplified, modified, or eliminated. A procedure was devised which took advantage of the results obtained and which closely followed the recommendations of Moon and Abou-Raya, Jour. Sci. Food Agr. 3, 407 (1952) for acid-insoluble lignin. The adopted procedure requires less labor than other methods and more samples can be analyzed in a given time. (For a description of the method, see "Useful Techniques" section).

The modified lignin procedure was used in analyzing a number of forages of known digestibility. Some of the results appear in Table 2. In line 1 appear bromegrass data from two stations. In line 2 are bromegrass data from a third station which do not agree closely with the data in line 1. If all the bromegrass data are grouped together, as in line 3, the regression equation is changed only slightly from that of line 1 but the standard deviation is greater. Orchardgrass, timothy, and Kentucky bluegrass, lines 4, 5, and 6, have regression lines not too distant from those of bromegrass. That of Sudangrass, line 7, is different but there were only 4 samples of Sudangrass and they fall close to the regression lines of the other grasses. Reed canarygrass alone appears to differ markedly from other species of grass. Two general equations for grasses are given in lines 9 and 10. In line 9 all samples of bromegrass, orchardgrass, timothy, Kentucky bluegrass, and Sudangrass are included, and of the grasses only reed canarygrass is excluded. In line 10 are the same except that bromegrass from line 2 is also excluded. There is no material difference between the calculated data in lines 9 and 10 except that the standard deviation is greater in line 9.

From the above it appears that a general linear regression equation, $Y = 100 - 6X$, could be used to predict with reasonable accuracy the digestibility of dry matter from the lignin content of orchardgrass, bromegrass, timothy, Kentucky bluegrass, and Sudangrass. When 60 samples of these species were examined in this way, in 39 of them prediction of the digestion coefficient of dry matter was made within ± 2 .

The last three lines of the table contain data on legumes. Alfalfa, alfalfa silage, and red clover silage with some admixture of alfalfa were predicted with fair accuracy from their lignin contents, but the same equation could not be used for all.

For 36 samples, all of grass, on which energy data were available, the coefficient of correlation (r) between the digestion coefficient of energy (D.E.) and the percentage of lignin (X), and the regression values were as follows:

$$r = -0.94; \text{ D.E. } = 98.0 - 6.21 X; \text{ S.D. } = 2.3.$$

Table 2. Summary of data between percentages of acid-insoluble lignin and digestion coefficients of dry matter in forages obtained from state experiment stations.

<u>Species</u>	<u>No. of samples</u>	<u>Coef. of correlation</u>	<u>Regression equation</u>	<u>Standard Deviation</u>
1. Brome	13	-0.99	97.8 - 5.57 X	0.9
2. Brome	12	-0.53	78.7 - 2.97 X	2.9
3. All brome	25	-0.86	96.3 - 5.67 X	3.1
4. Orchard	18	-0.89	103.8 - 6.62 X	2.7
5. Timothy	9	-0.92	98.4 - 5.91 X	1.8
6. Kentucky blue	4	-0.99	93.4 - 4.68 X	0.6
7. Sudangrass	4	-0.94	151.5 - 15.45 X	0.9
8. Reed canary	12	-0.68	73.3 - 2.11 X	2.3
9. Sum, 3-7 incl.	60	-0.90	99.8 - 6.11 X	2.8
10. Sum, 1, 4-7 incl.	48	-0.95	100.8 - 6.16 X	2.1
11. Alfalfa	27	-0.75	81.6 - 2.10 X	2.7
12. Alfalfa silage	5	-0.98	79.3 - 1.83 X	0.6
13. Red clover silage	12	-0.90	85.7 - 1.87 X	1.8

Plant Climate

Climate and plant growth studies (1957 Annual Report, page 20) were continued. Air temperatures and humidities were measured at the 5-foot height and also in the microclimate at 3 inches. Plant temperatures were measured in a stolon of Ladino clover, and soil temperatures were recorded at depths of 1, 2, 4, 8, and 16 inches beneath a Kentucky bluegrass sod mown at a 1-1/2 inch height.

During 1958 climatic conditions were generally favorable even though precipitation was below normal during 8 months. Only during the latter part of May was moisture limiting for several weeks. Air temperatures were normal or below except during April which was 2.9° F. above normal. The mean June temperature was 4 degrees below normal. An extreme deviation from normal occurred during December when air temperatures were 9 degrees below normal, and the soil was frozen to a depth of 16 inches by mid-December. This is in contrast to the mid-February date at which time freezing to this depth had frequently occurred.

Snow-cover at depths of 1 to 8 inches was present most of January, February and December. Minimum stolon temperatures between 7 and 12° F. were measured during January and between 15 and 19° the following December even when sub-zero air temperatures prevailed at the 5-foot height.

Extremes in summer temperatures of the stolons were not great. High stolon temperatures of 100 to 106° occurred on 4 days in early June and again they were 101 to 105° on 4 days in mid-August. Both of these periods occurred soon after a cutting. Favorably frequent precipitation during most of the summer favored leaf growth and this shaded the stolons and prevented development of extreme temperatures.

Temperature and Plant Growth

Studies conducted in the plant growth chambers (1957 Annual Report, pages 20-21) were continued. These include comparisons of the four possible combinations between alternating and constant air and soil temperatures. The two mean temperatures studied in 1958 were 60° F. and 70° F. Similar studies will be conducted in 1959 at 80° F. and 50° F.

Germination trials of 100 seeds were conducted in soil using triplicate pots at alternating and constant temperatures at 60° and 70° mean temperatures. It was apparent that alternating temperatures markedly increased emergence of Kentucky bluegrass at mean temperatures of 60° and 70°. The total emergence of orchardgrass was also increased. Increased emergence by alternating temperatures was also evident for birdsfoot trefoil and Ladino white clover but only at the 60-degree mean temperature.

The number of days required for complete emergence ranged from 4 to 20 and varied with the temperature and the species. Because seedlings of several species such as Kentucky bluegrass and orchardgrass emerged over extensive intervals and emergence of the other species was grouped, comparisons of the treatments are more valid when the "time of emergence" is considered as the number of days required for half or more of the total number to have emerged.

Emergence was between 2 and 5 days sooner at 70° than at 60° but differences caused by alternating and constant temperatures under these conditions are small and probably are not important.

Plant growth of the seedlings was measured as the dry matter produced by each of the 4 grasses and 4 legumes grown for 6 weeks after emergence. Five plants were grown in each pot and 3 replicate pots were used in each treatment. These conditions included all possible combinations of alternating and constant soil and air temperatures for daily means of 60° and 70° F.

For the alternating temperatures, the maximum occurred at 1 p.m. and the minimum at sunrise. This is the same as that on clear summer days for air at the 5-foot height and soil at the 4-inch depth. Because soil temperatures in the chambers are controlled by immersing the pot into a brine which is heated or cooled, the same temperature occurs at all depths.

The growth obtained under mean temperatures of 60° and 70° F. varied with the species and with the period of the day when the temperatures occurred. At a mean temperature of 60° F., poorest growth was obtained when both air and soil temperatures were constant and greatest growth occurred when soil temperatures alternated.

Growth at 70-degree mean temperatures was greater for several species and less for others. Dry matter produced under constant air and soil temperatures was not generally the lowest as it was at 60°, but alternating soil temperatures with constant air temperatures resulted in relatively greater growth of all species.

Similar experiments will be conducted in 1959 using mean temperatures of 50° and 80°.

Times of First Cut of Alfalfa for Hay or Silage

For the fourth consecutive year the first spring cuttings of plots of Ranger and Vernal alfalfa were taken at the (1) pre-flower bud, (2) full flower-bud, (3) first sign of bloom, and (4) half-bloom stages. Two summer cuttings from all plots at about the half-bloom stage were taken in mid-July and late August.

The total seasonal production from all treatments was 4 tons per acre even though the yield from the first cutting of the bud stage was but $1/3$ to $1/4$ that obtained from cuttings made at the half-bloom stage. Mid-summer yields were about one ton from all cuttings and late summer cuttings were greater from the plots cut earlier.

Results in 1958 repeat previous observations (1956 Annual Report, page 20) that indicated earlier cutting of alfalfa provides equivalent total yearly production with a better distribution and no loss of plants.

Facilities have not been available for feed analyses of the herbage removed at the different dates. Samples from these trials are available and it is hoped that means will be found to obtain such feed quality measurements. Preliminary trials indicated that early cutting provided a higher quality forage than that obtained from later harvests, when the lignin content of the herbage was greater.

Legume Seeding Establishment

Studies on the emergence of alfalfa and Ladino clover (1957 Annual Report, page 22) seeded in rows on small field plots were continued in 1958. Seedings at a $1/4$ -inch depth and without a companion crop were made in duplicate rows on four replicate plots. One hundred seeds of Ladino clover and 50 seeds of alfalfa were used in each of the rows on each plot. Planting times were at approximately 3-week intervals from April 14 to June 13.

At intervals of a week or less after seeding, counts were made of the number of visible alfalfa and Ladino clover plants in each row where a seeding had been made.

The occurrence and the amount of precipitation was recorded for each day as were also the maximum and minimum air temperatures at the standard 5-foot height. Emergence as percent of the total number of seeds planted, the daily precipitation, and the weekly averages of daily mean temperatures indicate that seedling stands were appreciably better in 1958 than in 1957. The good distribution of rainfall and below normal temperatures probably account for much of this. That slightly poorer emergence occurred from seedings made

May 2 and May 15 probably was occasioned by slight rains of only one-half inch occurring a week apart. The good rains in early June and again after the 15th provided excellent moisture conditions for the late May and June seedings.

While the weather that occurred in April, May and June 1958 may have been unusually favorable, it emphasized the importance of trying to select times for seeding that are apt to be followed by periods when precipitation could be expected to be more frequent.

Growth of Ladino Clover Seedlings in Association with Orchardgrass

Observations (1941, 1944, 1945, 1946, 1952, 1953 Annual Reports) suggest that heavy growth of orchardgrass both in field plots and in the greenhouse inhibits the growth of Ladino clover. To eliminate soil moisture and fertility as variables, equipment was assembled in the greenhouse where orchardgrass and Ladino clover could be grown in nutrient solutions. Preliminary studies in 1957 indicated that clover seedlings were adversely affected by orchardgrass growing in the same container. Also when the plants were grown in separate containers but were supplied with a nutrient solution that flushed both the grass and the clover, clover growth was reduced.

Studies in 1958 using gravel cultures were conducted in the greenhouse during the fall and winter months. Temperatures were controlled at 70° F. and the daylength was increased to 16 hours with light at 40-60 footcandles intensity from Mazda lamps. Four replications of each treatment were used.

The orchardgrass and clover were both grown in gravel cultures supplied with a nutrient solution containing ample amounts of N, P, K, Ca, Mg, S, Fe and minor elements for good growth. The nutrient solution flushed the roots at one-hour intervals while the plants were small and less frequently as the plants became larger and more solution was retained by the roots.

The orchardgrass was started from tillers of a vigorous clone, and the clover from seedlings that were germinated separately until the trifoliate leaf had appeared and then transplanted into the nutrient culture crocks.

Two primary objectives were included in these trials. One was to determine the effects of age of the orchardgrass plant on its inhibitory action. The second was to confirm earlier observations that inhibition of clover growth was not due to competition for nutrients, water, or light but that there may be a substance unfavorable for clover released by the orchardgrass into the nutrient solution.

To determine the effects of the size of the orchardgrass plant, tillers were started at three intervals, about a month apart from late September to early December. The clover was planted in all pots of orchardgrass on the early December date. On this date, clover was also planted in nutrient solution which was not changed but the necessary amounts of N, P, K were maintained.

In the event that an inhibitory substance might accumulate in the nutrient solution, the entire solution in one series of each age group was renewed weekly. In the remainder of the pots the solution was analyzed weekly and sufficient N, P, K, and Ca were added to replenish whatever had been used by the plants.

To eliminate competitive effects of the above-ground parts of the grass on the growth of the clover, another series was used in which the two species were grown in separate pots but were flushed with nutrient solution from the same reservoir. This nutrient solution from both pots returned to the same reservoir and thus was mixed prior to the next flushing. If a substance was released by the orchardgrass it would thus bathe the roots of the clover during the repeated flushings. This series of pots also included some cultures where the nutrient was changed, and some where it was not changed but adequate amounts of N, P, and K were maintained by additions of these elements.

Measurements of the sizes of clover in 4 replications of several treatments indicated that the increase in the size of clover planted in cultures with month-old orchardgrass and nutrient changed weekly was almost as rapid as that where the clover was planted alone. Planting clover into pots containing orchardgrass 3 months old greatly retarded growth of the clover even when the entire nutrient solution was changed weekly. When the clover was planted in separate crocks but supplied with nutrient which had been in contact with roots of orchardgrass, growth of the clover was greatly inhibited. Completely changing the nutrient solution decreased the inhibition but did not remove it.

In 2- and 3-month-old orchardgrass series, where clover was planted in the same pot with the orchardgrass and the nutrient solution was not changed, the orchardgrass was clipped at height of three inches above the gravel on the day the clover was planted. In both age groups, the clover was larger where the orchardgrass had been clipped, and also clover growth was greatest where the orchardgrass was youngest.

Effect of Temperature on Phosphorus Uptake by
Red Clover Growing in Nutrient Solutions
Containing Various Levels of Phosphorus

An experiment was conducted in the greenhouse to work out the technique to be used in the growth chambers and to determine the levels of phosphorus to be used in the nutrient solutions. Concentrations of 0, 0.01, 0.05, 0.10, 0.40, 1.60 and 6.40 ppm. phosphorus were maintained. The data obtained from this investigation indicate that a concentration slightly greater than 0.40 ppm. phosphorus is necessary for maximum growth of red clover and little, if any, growth is obtained at the 0.01 and 0.05 ppm. phosphorus. However, the levels of available phosphorus may not have been as high as planned due to too slow a rate of flow of the nutrient solutions or some of the phosphorus may have been tied up in a form unavailable to the plants. Phosphate analysis of the effluent solutions indicated that the phosphate levels were fairly well maintained. A slight precipitate formed in the tubing and pots in which the plants were growing. The precipitate was believed to be an iron compound. During the later part of the experiment iron was added to the solutions every five days at a concentration of 1.75 ppm. rather than everyday. This resulted in a large increase in the amount of root growth, particularly at the higher concentrations of phosphorus, and a gradual disappearance of the precipitate.

The experiment is to be repeated in order to determine more definitely the effect of various levels of phosphorus on the growth of red clover. It is hoped that the difficulties involved in the first run can be eliminated.

Effect of the Extract of Orchardgrass Roots on
the Germination of Ladino Clover

The results of germination tests of Ladino clover in Petri dishes containing aqueous extracts of roots of orchardgrass suggest that the roots of orchardgrass may contain a substance which is toxic to Ladino clover seedlings. The degree of toxicity appears to vary with the clone of orchardgrass. The earlier maturing clones were somewhat more toxic than the late maturing clones. The toxic substance had only a slight, if any, effect on the percent germination but did inhibit the growth of the seedlings. Germination tests were also conducted with birdsfoot trefoil and red clover using the aqueous extract of the roots of an early and a late maturing clone of orchardgrass. The response of birdsfoot trefoil and red clover was similar to that of Ladino clover but to a lesser degree. There appeared to be a greater inhibition of seedling growth than of germination. The aqueous extract of the early maturing clone was more toxic than that from the late maturing clone.

Germination tests of Ladino clover and birdsfoot trefoil were also conducted using aqueous extracts of the roots of timothy and brome grass. The percent germination did not appear to be adversely affected but there was an inhibition of seedling growth. Thus, it appears that orchardgrass is not the only grass which inhibits the seedling growth of Ladino clover and that this inhibition of seedling growth is not limited to Ladino clover.

USEFUL TECHNIQUES

Rearing Sitona hispidula Larvae

A procedure was developed for rearing larvae of the clover root curculio, Sitona hispidula for various experimental uses. Adults were swept from alfalfa in October and were stored at 40° F. As eggs were needed, adults were confined in an oviposition chamber set over a funnel at room temperature. Eggs were incubated 7 days at room temperature and were then brushed onto soil around potted alfalfa plants in which holes had been previously made to guide hatching larvae to plant roots. Pots were wrapped in aluminum foil, plants were cut back and were watered sparingly and held in the greenhouse at 60° F. to 65° F. The method gave 25 percent recovery from eggs to half-grown larvae. (For details, see Jour. Econ. Ent. 51(6):917-918, 1958).

Inoculation Technique - Pseudopeziza medicaginis on Alfalfa

A new method was used in screening plants for resistance to Pseudopeziza medicaginis. The basic idea of the method was obtained informally from Dr. Fred I. Frosheiser, Crops Research Division, St. Paul. A large bench was set up in a room in the headhouse with a chicken-wire frame (for supporting inverted cultures) raised three feet above and the whole thing covered with clear plastic sheeting. Several large pans of water were placed underneath the bench. A small electric hot water heater (with thermostat) in one pan heated the water to approximately 5° F. higher than the desired air temperature. This increases evaporation, thereby raising the relative humidity and moisture in the air to saturation.

The method eliminates the need for a humidifier which either puts on too much water (thereby washing-off spores from leaves) or not enough to keep plants moist on outside edges of inoculation bench.

Inoculation Technique - Bacterial Wilt
Organism (Alfalfa)

Being familiar with methods of inoculating with leaf-spotting bacteria, modified procedures were tried with Corynebacterium insidiosum, the bacterial wilt organism of alfalfa. Bacteria were introduced into alfalfa plants as follows:

Pin pricks into leaflets; into petioles, into petiolules and into the petiole at the junction of the two-side leaflets and by water soaking leaves with a bacterial suspension.

The method of dipping a needle into a bacterial colony and inserting it into the petiole at the junction of the two-side leaflets appeared to be best. Many of the inoculated leaves on the susceptible cultivar, Narragansett, would become yellow and curled while most inoculated leaves of Vernal, a resistant cultivar, would remain unaffected.

A More Rapid Method for Lignin Determination

Weigh 1-2 grams forage, ground to pass a 40-mesh screen, into a beaker. Add about 30 ml. benzene-alcohol mixture (2.5:1) and warm a few hours on the steam bath. Pour into a Gooch-type crucible with fritted Pyrex disc, size 30C, containing an asbestos mat and wash 2-3 times with benzene-alcohol, 3 times with acetone, and 3 times with water. Transfer, together with the asbestos, back to the beaker and add about 40 ml. pepsin solution in HCl. Digest 20-24 hours at 45° C. Pour through the same crucible, and wash with water. Pour about 25 ml. concentrated HCl through the crucible, adjusting the rate of flow so that the time of contact of the acid with the sample is about 2 minutes. Wash with water, and with alcohol and ether and allow to air-dry. Add 72 percent sulfuric acid in an amount sufficient to cover the sample, stir with a short rod, and allow to remain at 20° C. for about 3 hours. If the crucible is placed in a 50 ml. beaker it will catch the acid which slowly percolates through the crucible and which is to be discarded. Add fresh acid if it is necessary to keep the mixture fluid. Then return the crucible to the suction flask and remove the acid by suction. Wash thoroughly the residue in the crucible with hot water. Dry overnight at 105-110° C. and determine the lignin by the loss in weight on ignition at 500° C.

Flowering of Alfalfa Seedlings under Winter Greenhouse Conditions

For genetic and cytogenetic purposes, the life-cycle of alfalfa seedlings can be completed in the greenhouse during the winter. At this time more days are needed before flowering because available natural light is a limiting growth factor in greenhouses throughout the Northeast.

Seed directly or transplant seedlings into 4-inch painted clay pots with fertilized and inoculated soil. Maintain temperatures of approximately 60° F. to 70° F. When the plants are four weeks or older subject them to a "long-day" treatment either by (1) extending the natural day to 16 hours, using 40W incandescent light per 20-30 plants, or (2) interrupting the night with 200W light for 1 hour at midnight. Depending upon the genetic constitution and age of the plant material, flowering will occur from two to three months after onset of the "long-day" treatment. Treatment (2) gives the same results as treatment (1) when greenhouse temperature is 70° F., but delays flowering by two weeks or more if the temperature is 60° F. Increasing light intensity in treatment (1) by using 200W light instead of 40W did not shorten the time to flowering.

Converting Meat Coolers to Growth Chambers

Two military surplus meat coolers 8 feet square and 8 feet high were obtained to provide chambers wherein plants could be grown under controlled light and air temperatures.

The insulated top of each chamber was replaced with two layers of 7/32" double strength window glass arranged with a 3-inch air space between them. To support the glass, two 3/4" angle irons were bolted three inches apart with the top angle iron flush with the top of the chamber. The ends of crossbars of tee iron were bolted to the angle iron to make a support for 4 glass sheets approximately 44" x 44" and thus provide one of the 8-foot square glass covers. A similar glass arrangement was mounted 3 inches above it to provide an insulating air space between them.

Above the top glass, twenty-eight 96-inch power groove lamps were mounted by fastening the sockets for the lamps to a wooden frame at the top of the chamber. Two-lamp lead-lag ballasts were used and these were mounted on separate planks about 1-1/2 feet above the chamber. Small snap switches were placed in the circuit of the lead-wires to the ballasts and lamp wires from the ballasts were taken to the sockets. In this way different pairs of lamps could be used if the maximum intensity of 1400 footcandles 3-1/2 feet below the lamps was not always required.

The main electric power requirement of the lamps for each chamber is of an amount (about 40 amperes at 220 volts) that a relay switch is necessary and this relay may be operated manually or by a time clock.

The temperature control mechanism on the cooling compressors was not adaptable for growth chamber work between the range of 20 to 90° F. Thus solenoid valves were installed in high pressure refrigerant line. These electric valves are operated by a thermostat with its sensing bulb in the chamber. Temperature control in the chambers is about ± 2 degrees F.

Satisfactory air circulation within the chamber is provided by the fan moving air over the refrigerating coil. Plans are being made to be able to increase the air temperature in the chamber when this may be desired.

RESEARCH AT BELTSVILLE, MARYLAND

Title: CLOVER RESEARCH

Leaders: E. A. Hollowell and K. W. Kreitlow

A red clover date of seeding test with plantings of Kenland at two-week intervals from January 15 to June 1, alone and with winter wheat was established to determine the effect on the establishment and persistency of stands. Different herbicide treatments have been added in cooperation with the Crops Protection Research Branch. Plantings made from February 15 to March 15 produced superior stands that persisted throughout the summer months of the first year under favorable moisture conditions, better than other dates.

In a study to determine the effect of date of seeding and fall clipping on the incidence and severity of injury caused by the crown rot disease S. trifoliorum, Dixie crimson clover was seeded at 3 dates - August 30, September 15 and September 30. Clipping vs. non-clipping treatments were made when the growth reached 3 to 4 inches to simulate grazing. Irrigations were made to supplement rainfall whenever soil moisture was not sufficient to promote rapid stand establishment. Two years' data indicate that the incidence and injury from crown rot disease can be controlled by removal of the fall growth.

Title: BIRDSFOOT TREFOIL BREEDING

Leaders: P. R. Henson and N. G. Brandenburg

Plant losses due to root rots account for 70 percent or more of all plants of most of the various seed lots of birdsfoot trefoil which have been tested in spaced plantings at Beltsville, Md. Tests are under way to determine if surviving plants carry resistance or tolerance to root rots. Preliminary information on this point was obtained from studies of progenies of diallel crosses of 5 plants, three of which were classed as susceptible and two as resistant or tolerant. Three replications of 16 plants each of each cross were transplanted to the field in May 1957. The plants were cut at the full bloom stage in June 1958. The plants recovered well after cutting but evidence of disease became apparent in mid-July. Final plant losses were recorded in October, as shown below:

<u>Crosses involving:</u>	<u>No. of Plants</u>		<u>% Dead</u>
	<u>Total</u>	<u>Dead</u>	
3 susceptible plants	184	150	82
3 susceptible x 2 resistant	401	150	37
2 resistant clones	45	3	7

Analyses of the data indicated that the differences in survival were highly significant.

Title: DISEASE INVESTIGATIONS

Leader: K. W. Kreitlow

Diseases of Perennial Legumes: Investigations of losses in birdsfoot trefoil due to root rots were continued. Examination of diseased roots in different seasons suggested that root rot does not start until after at least one summer season and one winter season of growth. In addition to numerous fungi that have been isolated from diseased roots, several species of nematodes have been encountered. These will be tested in cooperation with nematologists to determine what role they play in the root rot complex.

Alfalfa Diseases: At Beltsville, Maryland, four S-1 seedling populations from indicator clones were tested against two type cultures and four strains of the bacterial wilt organism (Cornebacterium insidiosum). Two of the S-1 populations were as uniformly susceptible to wilt bacteria as the parent clones. Isolates of the recently described bacterial wilt organism from Italy were found to be indistinguishable in culture from isolates collected in different parts of the United States. Cooperative investigations are underway with nematologists at Beltsville to determine whether nematodes are possible agents for introducing the wilt bacteria into roots of alfalfa plants. Cooperative tests are being conducted with the Delaware Agricultural Experiment Station to determine whether variants of the organism can be distinguished chromatographically with respect to amino acids and sugar content. Cultures maintained under constant conditions for more than 1 year suggest that some strains of the bacteria can be maintained in a stable condition whereas others are highly variable.

Grass Diseases: Spaced plants of Kentucky bluegrass in field plots were infected with stem rust and yellow leaf rust. Some bluegrass lines appeared to be more susceptible to one or the other. Nine clones of Kentucky bluegrass were selected as differential lines for typing 14 single-sori rust isolates. These will be the basis for determining rust reaction types among plants tested for resistance.

A higher incidence of stripe smut caused by Ustilago striiformis was observed in turf plots of breeder and commercial Merion Kentucky bluegrass than in other varieties and selections. While most varieties averaged less than one smutted tiller per square foot, breeder and commercial Merion Kentucky bluegrass averaged 39.6 and 32.4, respectively, per square foot. Of the varieties and selections examined, Park, Delta, Arboretum, Newport and two Pennsylvania selections (K-1 and K-34) resisted infection.

Title: PASTURE RESEARCH

Leaders: D. E. McCloud and C. W. Alexander

In the growth room at Plant Industry Station, Beltsville, seedling growth was measured at soil temperatures of 40, 50, 60, 70, 80, and 90° F. The air temperature alternated from a low of 50° at 5:00 a.m. to a high of 70° at 2:00 p.m. Fluorescent lamps supplemented with some incandescents provided 1000 footcandles of light during a 12-hour day.

This study was intended to complement that being conducted in the climate chambers at the U. S. Regional Pasture Research Laboratory. An air temperature condition and the same lots of orchardgrass, brome grass, birdsfoot trefoil, and red clover seed as used at the laboratory were included at Beltsville. Additional species studied here were tall fescue, timothy, alfalfa, and white clover.

The influence of soil temperature on the growth of each species after 23 days is shown in Table 1. Dry-matter accumulation after 56 days growth is shown in Table 2.

Table 1. The average height (inches) of individual plants of some forage species grown at various soil temperatures.

Species	Age: 23 days					
	Soil Temperature °F.					
	40	50	60	70	80	90
Grasses:						
Orchardgrass ¹	2.1	4.2	5.2	9.7	7.5	8.8
Brome grass ¹	3.3	5.0	5.3	10.3	9.3	9.0
Tall fescue	3.1	7.1	7.8	11.3	12.2	11.4
Timothy	1.6	2.1	3.7	3.9	5.8	5.7
Legumes:						
Birdsfoot trefoil ¹	.7	.8	.8	2.8	3.4	3.9
Red clover ¹	1.0	1.2	1.7	2.6	3.2	2.6
Alfalfa	1.2	1.9	1.9	3.2	3.4	3.5
White clover	.8	.9	1.0	.9	1.6	2.1

¹These plants from same lots of seed used in a study at the U. S. Regional Pasture Research Laboratory.

Table 2. The average dry weight (grams) of individual plants (tops plus roots) of some forage species grown at various soil temperatures.

Age: 56 days

Species	Soil Temperature °F.					
	40	50	60	70	80	90
Grasses:						
Orchardgrass ¹	.20	.82	1.19	1.62	1.50	.40
Bromegrass ¹	Tr	.53	.37	1.06	.88	.74
Tall Fescue	Tr	.55	.73	1.36	1.51	1.17
Timothy	Tr	.11	.47	.33	.72	.58
Legumes:						
Birdsfoot trefoil ¹	Tr	.01	.01	.22	.30	.31
Red clover ¹	Tr	.10	.11	.44	.49	.27
Alfalfa	Tr	.04	.06	.10	.32	.11
White clover	Tr	.01	.03	.08	.19	.19

¹These plants from same lots of seed used in a study at the U. S. Regional Pasture Research Laboratory.

Title: FOUNDATION SEED PRODUCTION OF GRASS AND LEGUME VARIETIES

Leader: C. S. Garrison

The extensive production of certified seed of improved grass and legume varieties is directly related to the initial and recurring supplies of foundation seed. Unless adequate amounts of stock seed are maintained, a variety soon falls into disuse. The Foundation Seed Project in cooperation with the State experiment stations, seed trade and seed certifying agencies maintains breeder and foundation seed of five alfalfa varieties, three red clover varieties, two pearl millet varieties, and one variety each of orchardgrass and birdsfoot trefoil.

During 1958, the production and distribution of breeder and foundation seed involved cooperative work with 30 State experiment stations. The production of foundation seed amounted to 525,558 pounds with a value of over \$300,000. All the foundation seed, except 18,046 pounds, was grown under contract with the Commodity Credit Corporation. The value of the foundation seed purchased by CCC in fiscal year 1958 was \$283,008.05.

FOUNDATION SEED PRODUCTION AND COOPERATION
WITH STATE EXPERIMENT STATIONS IN 1958

Variety	<u>Foundation Seed Production</u>			No. of States Receiving Foundation Seed
	Amount (lbs.)	Acreage	No. of States	
Atlantic Alfalfa	-	-	-	1 ^{1/}
Buffalo Alfalfa	5,529	158.8	2	2
Narragansett Alfalfa	-	-	-	6 ^{1/}
Ranger Alfalfa	10,100	42	3	6
Vernal Alfalfa	153,479	1,006.5	7	12
Dollard Red Clover	19,076	42	2	8
Kenland Red Clover	181,326	338	2	7
Pennscott Red Clover	89,389	134.6	3	5
Potomac Orchardgrass	42,197	50	3	6
Starr Millet	-	-	-	4 ^{1/}
Gahi-1 Pearl Millet	11,224 ^{2/}	-	-	4
Line 13	2,295	7	1	-
Line 18	12,515	10	1	-
Line 23	7,136	13.5	1	-
Line 26	5,533	15	1	-
Empire Birdsfoot Trefoil	-	-	-	3

1/ Seed allotted from inventory.

2/ The amount of foundation seed resulting from blending an equal portion of live seed from each of the four inbred lines.

Foundation seed was distributed to 25 States and Canada.

Title: INVESTIGATIONS OF GENETIC STABILITY IN SEED OF IMPROVED
FORAGE CROP VARIETIES

Leader: C. S. Garrison

Data were obtained from the uniform clonal nurseries of alfalfa, birdsfoot trefoil, red clover, white clover, brome grass, orchardgrass, and timothy synthetic combinations located at Shafter and Tehachapi, California; Logan, Utah; and Prosser, Washington.^{1/} The data included dates and profuseness of flowering, classification of plant type, florets per head, seeds per floret, pod, umbel and panicle, percent fertility in the grasses, heads per unit area, seed yields, weight per thousand seeds harvested at different maturity dates, stand survival, disease ratings in orchardgrass, and head length in timothy.

Differences in stand survival for the birdsfoot trefoil clones at different locations were of particular interest when considered in terms of potential effect on genetic composition of a synthetic variety. Data on four clones, comprising one of the birdsfoot trefoil synthetic combinations, showed stand losses to be much higher by the end of the second harvest year at Shafter, California than at the other locations. The stand data by clones, years and locations, are given in the following table. Data for the several other factors have not been summarized.

Percent of original stand for four birdsfoot trefoil clones in the fall following harvest in 1957 and 1958 at three locations.

Location	CLONES							
	32-60		32-79		33-115		35-449	
	1957	1958	1957	1958	1957	1958	1957	1958
	%	%	%	%	%	%	%	%
Shafter, Calif.	100	52	82	6	39	22	82	28
Logan, Utah	98	90	100	83	100	93	100	99
Prosser, Wash.	100	91	100	95	100	70	95	68

The rooted cuttings were transplanted in California in February 1957; in Utah in May 1957; and in Washington in April 1957. The work is conducted in cooperation with the respective State experiment stations.

^{1/} See the 21st Annual Report of the Pasture Laboratory for details about the synthetic combinations included in these studies, and the latitude and elevation of the areas where seed is being grown.

REPORTS OF R. AND M. COOPERATIVE RESEARCH

Title: PROJECT NE-13 - THE MECHANIZATION OF FORAGE CROP HARVESTING, PROCESSING, STORING AND FEEDING

Leader: R. W. Kleis, Chairman, Regional Technical Committee

Cooperators: Storrs (Connecticut), Delaware, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York (Cornell), Pennsylvania, Rhode Island, Vermont, and West Virginia Agricultural Experiment Stations, the Agricultural Engineering Research Division, and the State Experiment Station Division, A.R.S., U.S.D.A.

PROGRESS OF WORK AND PRINCIPAL ACCOMPLISHMENTS:

(1) Harvesting. At Connecticut two instrumented conventional mowers were used in field investigations of friction energy and cutting energy with varying crops, yields, knife speeds and cutting rates. Supporting laboratory tests were conducted with an improved pendulum and instrumented units to isolate and evaluate energies and effects of variables on machine behavior. Laboratory studies of cutting action effects on regrowth of oats and alfalfa were conducted using time lapse photography and indicated no effects between severe bruising and sharp shearing.

Studies of effects of compaction and slippage by machinery tires at Massachusetts were directed at isolating the two actions and investigating their effects on recovery using various stages of maturity, tire pressures, loads and percents of slip. Both compaction and slippage resulted in significant reduction in subsequent yields, particularly in pre-first harvest treatments. Most severe yield reductions were 47 percent for compaction effects and 15 percent for 15 percent slippage. New Hampshire activities included the establishment of forage plots and development of procedures for basic investigations of tractor tire performance and legume recovery.

Continued investigations of hay conditioners were conducted by Maine, Massachusetts and West Virginia. West Virginia concluded this phase of their work with the observation that differences between the crimper and the crusher reported from closely controlled tests were not obvious in general use. Maine results indicate a drying time advantage of the crusher over the crimper in heavy yields. Massachusetts comparisons included both conditioners and the vertical flail harvester in tests of drying rates as somewhat incidental to studies of field losses but results confirm previous years' indications that the flail harvester expedites field drying more than conditioners.

West Virginia studies of both vertical and horizontal flail harvesters indicate efficient operation in standing crops. Excessive losses were observed in recovery from swaths and windrows by the vertical unit. Massachusetts reports relative losses (including stubble) corrected to 15 percent M.C. of 203 lbs./acre from conventional mower, 241 lbs./acre from mower-crusher; 228 lbs./acre from mower-crimper; and 411 lbs./acre from vertical flail harvester in hay making.

Other forage harvesting studies included work at Pennsylvania on the moisture distribution in alfalfa plants during the field curing process. Preliminary results suggest a need for closely controlled and extensive investigation of the relative drying characteristics of leaves and stems following various harvesting treatments. U.S.D.A. studies show more dry matter harvested per hour of harvester operation when grass silage is wilted and raked as compared to direct cut operation. Maine work on silage unloading has been concluded with the development of a false headboard wagon unloader and metering device which provides for uniform unloading and elevating with only one man - the truck driver.

(2) Processing. Several modifications were made in the wagon drying system and operating procedures at New Jersey. Efficiency was increased by moving the heating units inside of the drying shed. Variable speed fans provide for relative regulation of air volume and temperature as drying of a batch progresses to maximize the rate of drying. Operating costs were \$4.28 with fuel oil and \$5.00 per ton (in another system) with Propane gas. Work progressed on the development on controls and an automatic weighing system.

Pennsylvania observations and data on the operation of a four wagon batch (recirculating) drying system indicates an average operating cost of \$2.50 per ton of dry hay with 40 percent initial moisture content.

Results of laboratory drying tests of chopped hay were analyzed for representation mathematically at New Jersey. The applicability of several mathematical relationships of temperatures, moisture contents; air velocities and time are suggested for deep bed drying. These basic relationships are vital to understanding the drying process for operation analysis and system design.

Tests and observations of the continuous baled hay drier were continued at West Virginia with some modification of design. Efficiency decreased with temperatures in excess of 180° F. with fuel costs of \$5.00 to \$7.50 per ton at 250° F.

Laboratory investigations were conducted at Pennsylvania on effects of controlled simulated field conditioning treatments of hay. Tests on small samples included smooth rolls (crushing), fluted rolls (crimping) and a combination of smooth and fluted rolls. All conditioned samples oven dried faster than the control samples and at feed velocities of 500 to 1000 feet per minute conditioning treatment effects appear identical. Some samples conditioned with these laboratory units were subjected to infrared radiation of 2.5 watts per square inch. This level of radiation had no pronounced effect upon the drying rate.

Energy requirements for pelleting forage with an impact type machine received attention at Pennsylvania. Satisfactory pellets were made with pressures of 4000 pounds per square inch. This work confirms previous findings that a moisture content of less than 25 percent is necessary for satisfactory pelleting. Methods of forming hay cakes were investigated at New York. Crimping hay stems to cause interlocking at the edges of the cake increases its durability. This crimping can be accomplished by cutting the hay to a larger diameter than that of the forming tube.

(3) Storing. Investigations of pneumatic handling of chopped forage continued at Maryland, with emphasis on the development of methods of obtaining uniform flow of materials into the air stream. Several modifications in design of this well instrumented test system have not yet resulted in a completely satisfactory feeding system. The maximum conveying rate obtained for a load was 6.0 tons of 20 percent hay per hour. System components are powered individually for horsepower readings. New Jersey has assembled and developed instrumentation and equipment for studying the Silorator blower system.

The belt-tube elevator was modified and further developed at Cornell for elevating silage. Increased belt contact in the upper section and a semi-mechanical conversion section have resulted in satisfactory performance with both smooth and rough belts. Further work on cross section design should result in a substantially more efficient elevating system than other methods involving throwing or blowing.

A 48-foot flight elevator was modified at Pennsylvania by replacing cross flights with small staggered flights on two individual chains. Capacities up to 10 tons per hour were achieved with a 26-foot lift with a 3-horsepower motor. Material with a moisture content of over 35 percent gave wrapping trouble.

The belt type mow distributor for chopped hay was used successfully by Cornell again this year. The belt distributor at Pennsylvania was converted to three chains with attachment links. Satisfactory distribution of 70 percent of the material occurred in the first 20 feet of the 38-foot unit.

An auger type mow unloading unit has been designed and fabricated at Massachusetts for preliminary testing this winter. The unit is limited to chopped hay and unobstructed storages. It is designed to remove about 95 percent of the hay from a square storage segment of varying size and deliver it to a mechanical or self-feeder with moderate power.

Properties of forage affecting storage and handling are being investigated at two stations. New Jersey continues an intensive study of silage characteristics affecting behavior in storage and self-feeding. Self-feeding silo design and operating procedures are being further developed accordingly. Massachusetts has begun investigations of physical properties, behavior and storage requirements of intermediate moisture content forage. One year's work with laboratory units provides limited basic data on friction, compaction and freezing properties as well as effectiveness of various construction and sealing materials for sealed storage.

The U.S.D.A. conducted storage studies of factors affecting wall pressures on horizontal and vertical silos. In an 8-foot deep horizontal unit an average lateral pressure of 140 pounds per square foot and an average vertical pressure of 76 pounds per square foot were recorded. This relationship is exaggerated with increased densities.

(4) Feeding. Further development and improvement of self-feeding tower silos is resulting from work at New Jersey. Increased understanding of the characteristics of silage is being applied to the control of its downward descent. Rotating pins have been used to replace sliding control pins for easier operation. A double baffle is being tried to replace the pins in the pin - baffle system. Brackets to check the descent of silage have been installed for livestock safety.

Vermont work on conveyor feeding in stanchion barns has concentrated on equipment for quantity control of hay, grain and silage for a completely mechanized system. A silage meter (weighing unit) can provide 9 to 39 pounds per cow in increments of 3 pounds. An automatic silo unloader lowering device is to be tested this winter. The development of a grain metering device is completed. Work is being done on the mechanization of gravity discharge bulk grain bins to overcome budging.

West Virginia designed, built and successfully used a combination self-feeding and self-unloading wagon. The addition of a false endgate converts the feeding rack to an unloading wagon for harvest operations. The "push button" feeding system for beef cattle is being used in comparative studies with the box silo, a Harvester and hand feeding from a conventional tower silo.

USEFULNESS OF FINDINGS:

Information obtained on forage cutting characteristics and mower behavior will be significant in design of improved harvesting units.

Effects of cutting methods on crop recovery and crop properties on machine operation will assist in design for compatibility of crop and machine function.

Controls and metering equipment for unloading chopped forage at the unloading point reduced labor required to one man.

The benefits of studies and developments in field conditioners is being reflected in new units and their popularity in sales and use.

The flail Harvester studies show promise of combining mowing, conditioning and field chopping in one relatively simple machine.

Adverse effects on grass regrowth for both weight and slippage of harvesting equipment and the desirability of floating equipment have been established.

Investigation of field losses for various operations and mechanisms in harvesting can direct design and development of future equipment.

Both basic and applied investigations of three stations of forage drying can lead to more efficient and generally practical use of this practice in making quality hay.

The belt-tube and flight elevator promise increased efficiency and greater flexibility than current blower-throwers for placing chopped forage in storage.

Basic and controlled investigations of pneumatic handling systems can result in greater operating efficiency of this desirably simple mechanism.

Mow distributors and the silage distributor developed provide the operating advantages of uniform placement without manual effort.

Self-feeding of silage from tower silos and hay from mows and feeding wagons transfers major materials handling effort from the operator to the livestock.

Mechanical feeding in stanchion barns provides for combining major advantages of loose-housing into the stanchion system with its traditional features.

Quality control devices and procedures will increase the practicability of mechanical feeding for dairy operations.

Mechanical mow unloading can provide the link between mechanical placement in storage and labor free feeding for a complete system.

Harvesting and storing forage at an intermediate moisture content may provide for combining the desirable features of hay and silage and avoid the inherent problems of each.

Basic investigation of the physical characteristics and behavior of chopped forage at two stations has and will contribute to the sound formulation and conduct of applied research and development activities.

WORK-PLANNED FOR NEXT YEAR:

The project revision prepared and submitted this year was considered by the committee of three to represent insufficient change from the original project to require adoption. They recommended and the NE Directors endorsed the continuation of the original project for another year. This was not inconsistent with the feeling of the technical committee which considered the original objectives still valid and not yet accomplished. Project status and action for continued activity beyond this year were considered by the Executive Committee and subsequently by the technical committee in January 1959. As a result of their deliberations:

Basic studies of action, effects and energy requirements of forage cutting will be continued at Connecticut.

Field losses resulting from various harvesting practices and mechanisms will be studied more intensely at Massachusetts with particular attention to the rotary harvester.

Tractor tire performance and effects on legume recovery will receive attention at New Hampshire.

Pelleting investigations at Pennsylvania will be directed toward theoretical and laboratory analyses of configuration and dimensions for durability and handling efficiency.

Moisture migration in forage drying will be investigated at Maine and basic investigations and analyses of the drying process will be continued by New Jersey and Pennsylvania. Development of equipment and systems for drying will continue at New Jersey, West Virginia and Pennsylvania.

Elevators, conveyors, blowers and distributors will continue to be studied and developed for placement of forage in storage with minimum labor requirements at Maryland, New Jersey, New York, Pennsylvania. These activities will include both basic and applied studies on various aspects of this important general problem.

Development of methods and equipment for removal of chopped hay from storage will be continued at Massachusetts and started at New York. A new approach to silo unloading will be pursued at West Virginia.

Self-feeding from tower silos and ground level mows will receive continued attention at New Jersey.

Metering of hay, handling of baled hay and possible new forms of hay as related to mechanical feeding in stanchion barns will receive attention at Vermont.

Basic laboratory studies of the physical properties and storage requirements of intermediate moisture content forage will be intensified at Massachusetts.

Title: PROJECT NE-18 - ECONOMICS OF FORAGE PRODUCTION AND UTILIZATION

Leader: H. B. Metzger, Chairman, Regional Technical Committee

Cooperators: Connecticut (Storrs), Delaware, Maine, Maryland, Massachusetts, New Jersey (Rutgers), New York (Cornell), Pennsylvania, Rhode Island, Vermont, and West Virginia Agricultural Experiment Stations, the State Experiment Station Division, and the Farm Economics Research Division, A.R.S., U.S.D.A.

PROGRESS OF WORK AND PRINCIPAL ACCOMPLISHMENTS:

The year 1958 was devoted to closing out original contributing projects and initiating several new phases of work. Of the ten stations with participating projects, Vermont closed out its project as of June 30, while Maryland initiated a new contributing project as of July 1. Other stations were completing work under their original contributing projects and initiating new contributing projects, except that Pennsylvania did not undertake a new phase of work.

Physical and Economic Input-Output Relationships in Forage Production. Work previously initiated on costs of harvesting forage was completed except for publication of results. Time and motion studies of ensiling grasses were continued for the third year in six leading dairy counties of Massachusetts with emphasis on harvest combinations utilizing flail-type choppers, and elevators (Massachusetts). Synthesized combinations of machinery were applied to an actual farm setting where 420 tons of grass silage were harvested and costs for each determined. A Master's thesis was largely completed. Summary and analysis of comparative costs involved in green feeding of dairy cows as compared with conventional pasturing during summer months was completed (New Jersey). The work included a detailed analysis of amount and cost of labor and machinery for green feeding on 15 dairy farms. A Master's thesis was in preparation. The costs of operating silo unloaders was obtained on 38 dairy farms (New Jersey). Results indicated the advantage of large volume in reducing the cost per ton for mechanical unloading. A manuscript for an AE series publication was in preparation.

Other previous work with general application was also completed. In a cooperative study with agronomists, chemical tests and evaluation of crude protein and methoxyl of hay samples from 95 farms was completed and a review report prepared (Delaware). The variation in crude protein and methoxyl of samples from various farms appeared great enough to obscure differences in contents of these two constituents due to dates of cutting and times rained on after cutting. Individual estimates of two agronomists as to protein content were not clearly associated with the content shown by chemical tests. Analysis of data was completed and a tabular summary was prepared showing that farmers whose major source of income was from beef and sheep kept sizes of herds in proportion to forage production (West Virginia). Farmers with larger productions of pasture, silage, and hay had more livestock; increases in numbers were directly proportional to the increase in forage.

New phases of work were initiated to study further the existing patterns of forage production using the survey method. A survey was completed of forage production programs on 80 dairy farms in southern New Jersey covering the year 1957 (New Jersey). Emphasis was on the economic advantages of corn silage vs. legume crops for hay and silage vs. grasses with heavy fertilization. Analysis of data was started. A survey was completed of forage production on 1088 farms in the Plateau Region of New York (New York). Data obtained included acreage and production of forage and other crops, date of harvesting, costs for fertilizer and limestone, feed purchases, monthly deliveries of milk, and number of livestock. Farms were grouped into four land resource groups. Summary of the records was started. A survey was largely completed on 50 dairy farms in the Appalachian Valley of West Virginia to enable the analysis of the physical and economic input-output relationships of forages commonly used for winter feeding of dairy cattle (West Virginia). Data, obtained for individual fields selected on the basis of soil type, included: crop histories (rotations, treatments, seedings) harvesting data (date of harvest, quantity harvested, and method of harvest) and related information on farm organization.

New phases of work also were initiated to study patterns of forage production not in general use, using the experimental plot data of the plant scientists. Input-output data from experimental forage plots were obtained for 1957 and 1958, in a cooperative study with plant science workers, on various forage management practices in establishing and maintaining high yielding stands (Connecticut). Economic analysis is underway for two years of data but a third year of data will be obtained before final results are reported. Comparisons are being made of nine herbicides at three levels of treatments, and ten cutting systems each with four fertilizer treatments. Inputs of seed, fertilizer, etc. and yields of dry matter for corn, millet, sorghum and Sudangrass were determined for 1958 from experimental plots in a study of the economics of forage crop rotations conducted in cooperation with agronomists (Rhode Island). An alfalfa stand was established for comparative purposes in subsequent years. Data were also obtained on amount and cost of inputs and yields for the annual crops on several farms in the state.

Economic Effect of Alternative Combinations of Forage Production and Utilization on Farm Businesses with Different Resources and with Different Market Outlets. Work previously initiated to show the effect on net farm income of adopting various practices in growing, harvesting, and utilizing forages was completed and results were published or are ready to be published.

The analysis was completed and results published on the survey of 556 dairy farms in the North Country region of New York (New York). Differences in crop yield explained part of the variation in incomes on these farms, through their effects on livestock production. Farms with good crop yields produced more feed, principally roughage, which in turn meant more milk than on farms with poor yields. High crop yields were directly related to fairly frequent reseeding of the hayland and the application of liberal

amounts of plant food. Improving crop yields gave a much more favorable response in milk production per cow than adding more cropland to increase the roughage supply. A liberal supply of roughage was an important key to economical milk production. The farms with high-producing herds harvested nearly 50 percent more roughage per cow than farms with low-producing herds. Tonnage alone was not sufficient—poor quality hay was apparently a seriously limiting factor on some farms. The competitive position of this region in dairying hinges in large part on raising the level of milk production per cow by providing more and higher quality roughage.

Budgets on the profitability of alternative forage programs for farms representative of New Castle County, Delaware were completed and a Master's thesis prepared (Delaware). Four sizes of farms with four combinations of programs (with and without forage crop irrigation and capital borrowing) were analyzed allowing for field curing or heat curing and full or partial storage of hay. The budgeting did not include feeding the forages to livestock. Net returns on 50 acre farms varied from \$4350 to \$6648. The most profitable forage crop with limited capital and without irrigation was alfalfa.

An application of technical input-output information in alternative methods of procuring forage, reported previously, was made to representative farm organizations for 100 cow-, 200 cow-, 300 cow-, and 500 cow-farm units (Connecticut). Costs and returns for 192 budgets were prepared and a manuscript was nearly completed. Results are confidential until the final report is released.

Budgetary analysis of alternatives of pasture improvement and land renovation on eight typical northeastern Pennsylvania dairy farms was completed and a Master's thesis prepared (Pennsylvania). For most farms, renovation appeared to be a profitable step in the expansion of the total farm business.

A technical station bulletin was prepared and issued giving results of the budgetary analysis of the effect of soilage on farm profits (Rhode Island). Another farmer-type bulletin was in preparation showing how individuals may evaluate profit potentials of soilage on their own farms.

USEFULNESS OF FINDINGS:

Findings from these studies will assist farmers who seek information on the effect upon farm income of alternative forage patterns and practices under various farm situations. Since economic evaluations are essential to choosing profitable forage systems, results of these studies will provide an improved basis for decisions, thus assisting in preventing costly mistakes in management. Material assistance will be provided farmers in choosing from a wide range of cropping systems and harvesting methods the most profitable combination for their farms. The ultimate effect will be a more efficient and more profitable farm business.

Findings will prove to be useful in building the economic and agronomic phases of county extension programs in the region.

The work has stimulated research in related fields which should provide better methods of measuring forage stands and forage quality.

WORK PLANNED FOR NEXT YEAR:

Eight states will carry forward work under the project throughout the coming year. Vermont has terminated, and Pennsylvania will terminate, contributing projects.

Several manuscripts and Master's theses will be ready for publication. These will include reports on the costs of green feeding (soilage), the costs of harvesting grass silage, and the effects on net income of various forage programs.

Additional physical and economic data will be collected and analyzed on forage cropping systems and practices, and harvesting and storing systems and practices. The comparative costs and investments, and economic advantages will be determined for alternative systems.

Budgeting and linear programming of typical farm situations will be undertaken, using data collected under the initial phases of several studies. These will show effects on net farm income of feeding various kinds and amounts of forages to dairy animals.

Survey data collected on existing farm operations will be analyzed to show the effects of forage patterns and practices on yields of forage and livestock products.

Determinations of variations in dry matter recovery of hay under different drying treatments will be continued.

A revised regional project statement will be submitted under which current and revised state contributing projects will contribute to a further coordinated attack on three areas of work intended to:

1. Fill in some of the major gaps in our knowledge of the effects on investments, operating costs and returns of alternative forage patterns and practices used by farmers under different resource conditions.
2. Appraise the economic effects of new and improved forage systems and practices as revealed by experimental evidence.
3. Provide much-needed additional answers to farmers' questions about the economic effects of alternative methods of curing and storing forages.

Title: PROJECT NEM-22 - FACILITATING THE MARKETING OF SEEDS THROUGH IMPROVED PROCEDURES FOR TESTING THE VARIETAL PURITY AND IDENTITY OF SEEDS OF VARIETIES OF PERENNIAL FORAGE CROPS RECOMMENDED AND/OR DEVELOPED FOR THE NORTHEAST.

Leader: B. E. Clark, Chairman, Regional Technical Committee

Cooperators: Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York (Geneva), New York (Ithaca), Pennsylvania, and Rhode Island Experiment Stations, the Crops Research Division, Forage and Range Research Branch, and the State Experiment Station Division, A.R.S., U.S.D.A.

PROGRESS OF THE WORK AND PRINCIPAL ACCOMPLISHMENTS:

Field plantings made in Rhode Island and at two locations in Pennsylvania in 1957 failed due to winter injury and were abandoned. The 1957 plantings in Maryland and New York had good winter survival and notes were obtained on these during the summer and fall of 1958. New plantings were made in Maryland, New York, Rhode Island, and at two locations in Pennsylvania. These new plantings consisted of 35 stocks of alfalfa, 14 stocks of birdsfoot trefoil, and 17 stocks of red clover. These included breeder, foundation, Certified, and non-certified stocks. The plantings are of a randomized block design with four replications. The plantings were successfully established at all locations and will be evaluated in 1959. Fall dormancy notes were obtained on the New York plots in 1958.

In New York plantings were made to determine the relative value of planting in broadcast plots, seeded rows, and rows of seedlings transplanted from the greenhouse in detecting varietal mixtures of alfalfa. Thirteen different mixtures of Ranger, Buffalo, and California Common and planted in four replications in broadcast plots, seeded in rows at two spacings, and in rows transplanted from the greenhouse. Unfortunately, the fall weather was such in 1958 that too much regrowth was made after the September 15 cutting and it was impossible to get good notes on fall dormancy. These plantings will be evaluated in 1959. Plantings were also made to compare broadcast plots and row plantings of birdsfoot trefoil. These will be evaluated in the spring of 1959.

Work has been continued in the artificial light chambers and the results have been encouraging. During January and February the temperature in the greenhouse section in which they are located was kept at approximately 50° F. for seven weeks. This produced temperatures of approximately 50° F. at night and 60° F. when the lights were on. Under these low temperatures eight-hour photoperiods with red and green light produced very striking differences between northern and southern alfalfa plants. With this treatment very nearly every plant of a southern type could be distinguished from plants of the northern varieties. One treatment under these low temperatures also gave good results with birdsfoot trefoil. This treatment, gold lights for 16

hours and green lights for 8 hours, produced plants of the European type that averaged twice as tall as plants of the Empire type. Further work needs to be done to develop methods of distinguishing intermediate types of alfalfa from northern types. Also methods are needed to distinguish Viking birdsfoot trefoil from European types.

During 1958 forage crop varieties were grown under 40 different conditions of photoperiod, light color, and temperature. Experiments were designed to investigate the following problems:

1. To determine the best proportion of red to green light in distinguishing types of alfalfa.
2. To determine how long the photoperiod can be and still produce a short day reaction with alfalfa and also to determine if this critical day-length varies with different colors of light.
3. To find conditions that will cause blooming in timothy in an early age.
4. To study the effect of dark and light cycles shorter than 24 hours.
5. To study the effect of light intensity on alfalfa plants grown under red and green light.

Results from these experiments indicate the following facts:

1. The proportion of 50% red tubes and 50% green tubes appears to be as good as any proportion of the two colors in distinguishing types of alfalfa.
2. As much as 14 hours of light per day can be used to produce a short day reaction with northern alfalfa. With this photoperiod of red and green lights the plants made rapid growth and good results could be obtained in as little as 5 weeks. Thus far it does not appear that the critical length of photoperiod for alfalfa varies with the color of the light.
3. To date it has not been possible to produce blooming in timothy at an early stage. However, much work remains to be done on this problem. Under red and blue light with a 14-hour photoperiod Climax makes somewhat faster growth than either Essex or Commercial timothy.
4. Light and dark cycles shorter than 24 hours do not appear to be as good as a 24-hour cycle in producing differences between alfalfa or birds-foot trefoil varieties.
5. The amount of difference in stem length between northern and southern alfalfa did not change much when the seedlings were grown under $\frac{2}{3}$ intensity of red and green light as compared to full intensity of approximately 410 footcandles. However, when seedlings were grown under $\frac{1}{3}$ intensity the growth was poor and the difference between types was less than in the case of seedlings grown under higher intensities.

Work was continued on the osmotic pressure test with birdsfoot trefoil seed. An experiment was conducted to see if this method could be used as an aid in conducting greenhouse tests. Eight stocks of Empire seed each known to contain a small amount off-type seed were germinated in plastic dishes in a salt solution of seven atmospheres. The temperature was kept at 65° F. and the first 10 percent of the seed to germinate under these conditions was taken out of the dishes. Seed that had not yet sprouted after five days was also taken out. These fast and slow germinating separates were seeded in flats and kept in the greenhouse at 65° F. for 7 weeks. At this time the plants were classified as European or Empire type. The results showed that 1.7 percent of the slow germinating seeds produced off-type plants. On the other hand, 9.3 percent of the quick germinating seed produced off-type plants. Thus the percentage off-type plants can be increased by selecting seeds that sprout quickly under osmotic pressure. This would increase the chances of detecting seed lots containing admixtures. A larger well replicated test with unselected seed could be used to get an accurate estimate of the percent of off-type seed in stocks found to contain admixtures.

Efforts to develop a quick test for resistance to bacterial wilt of alfalfa were continued. Five-week old plants of Ranger, Vernal, DuPuits, and Narragansett were immersed in a suspension of alfalfa wilt bacteria for 3-1/4 hours and for 6-1/2 hours. The seedlings were grown for five weeks at 68° F. and 82° F. Since long periods of immersion can cause symptoms to appear within two weeks, it was thought that symptoms might be produced at one of these temperatures that would make it possible to distinguish the susceptible varieties from the resistant varieties. Unfortunately, neither of these temperatures produced symptoms in the seedlings of the susceptible varieties without also producing symptoms in the resistant varieties.

Work was started during the year to determine whether seedlings of different types of alfalfa, red clover, and birdsfoot trefoil respond differently to applications of various chemicals. Dalapon and gibberellin were used for these experiments. Dalapon was injurious to all of these species and the young seedlings were killed unless the concentration of a solution sprayed on them was low. No differential response has been noted among types of red clover or birdsfoot trefoil. On the other hand, southern types of alfalfa appeared to have more ability to continue to grow after treatment than do northern types. This may be due to the fact that the southern seedlings were more vigorous and somewhat larger than the northern seedlings at the time of treatment, four weeks after seeding.

Gibberellin when applied at concentrations of 5, 10, or 15 parts per million stimulated the growth of alfalfa, red clover, and birdsfoot trefoil. This stimulation was not great for alfalfa or red clover, but was very striking in the case of birdsfoot trefoil. Fifteen-day-old birdsfoot trefoil plants were sprayed with a solution of 15 parts per million of gibberellin in water. The plants were measured three weeks later and it was found that the stems of the treated plants were four times as long as those of the untreated control. All three of the varieties tested responded about the same to the gibberellin as far as elongation of the stems was concerned. In certain

cases the number of stems for the treated European plants was greater than that of the treated Viking.

In the case of alfalfa the seedlings showed the effects of gibberellin treatment by a more rapid elongation of the stem. The southern types showed this stimulation sooner than the northern types.

The gibberellin treated red clover made more rapid growth than the untreated control. However, no differences could be observed between the varieties in this respect.

USEFULNESS OF FINDINGS:

A technique has been worked out which will detect southern type alfalfa seed with precision as great as that possible in the field. This test requires seven weeks or less instead of a whole growing season in the field. This will make it possible in some cases to detect mislabeled seed lots in time to prevent them from being planted in the field. Seedsmen have been greatly interested in using a greenhouse test developed to distinguish Empire from European type birdsfoot trefoil. Results obtained in the light chambers and with the osmotic pressure test should make it possible to improve the accuracy of this test. Results obtained in 1958 will be valuable in planning future research.

WORK PLANNED FOR NEXT YEAR:

In the field it is planned to evaluate the plantings made in 1958. New plantings will be made with four varieties of alfalfa. The plants will be spaced three feet apart in 3-foot rows. Detailed notes will be taken on each plant throughout the growing season. By using only four seed stocks the plant population can be limited to the extent that it will be possible to take notes on each plant several times during the year. It is hoped that this procedure will reveal characteristics that will aid in distinguishing the varieties. Another part of the field work will be to plant seeds in rows and clip at 3 different dates in the fall. In this way it is expected the best time to cut in the fall at each location will be determined.

With the completion of the climate chambers now under construction, the work with photoperiod and artificial light will be increased. The light conditions that have shown the most promise in the small chambers in the greenhouse will be used in the new chambers. These light conditions will be used in combination with different temperature treatments. These will include continuous high and low temperatures in addition to temperatures that vary between the day and the night. Seedlings will also be grown at different distances from the light source. This will produce different light intensities. The light chambers in the greenhouse will continue to be used. New combinations of light color, temperature, and photoperiod will be used in these. Gibberellin treatments of birdsfoot trefoil, red clover, and alfalfa will also be used in combination with different light color and photoperiod treatments.

Work with osmotic pressure on germinating birdsfoot trefoil seeds will be continued. Seeds of different age and germination percentage will be germinated under pressure to study the effect of these factors on varietal differences in respect to this test.

Further studies will be made on the effect of temperature on the development of wilt symptoms in alfalfa. When the climate chambers are completed, a wide range of temperature conditions will be available.

More work will be done to study the effect of chemicals on seedlings of alfalfa, birdsfoot trefoil, and red clover. New chemicals will be tried and further studies will be made on the effect of rate and time of application of gibberellin. The effect of gibberellin under different photoperiod and light color treatments will be studied.

Title: PROJECT NE-24 - THE NUTRITIVE EVALUATION OF FORAGES

Leader: J. T. Reid, Chairman, Regional Technical Committee

Cooperators: Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, Vermont, and West Virginia Agricultural Experiment Stations, the U. S. Regional Pasture Research Laboratory, the Animal Husbandry Research Division, Dairy Cattle Research Branch, and the State Experiment Station Division.

PROGRESS OF WORK AND PRINCIPAL ACCOMPLISHMENTS:

During the year the following state experiment stations had projects contributing to this regional project: Delaware, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, Vermont and West Virginia. Studies of a related nature were conducted by the United States Regional Pasture Research Laboratory and the Dairy Cattle Research Branch.

The main lines of study pursued during the year by one or more stations were: (1) the evaluation of forages in terms of digestible protein and digestible energy, (2) the evaluation of forages in animal-production trials, (3) the development of chemical and biological methods for the assay of nutritive quality and (4) the comparison of the nutritive qualities of forages as determined with different animal species.

Studies of the digestible protein and digestible energy value of 170 forages grown and harvested under known conditions have been made or are in progress in the region (Delaware, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, Vermont and West Virginia).

The forages studied include pure stands of alfalfa, brome grass, orchard grass, reed canary grass, oat, birdsfoot trefoil, timothy, red clover, Kentucky bluegrass and mixtures including these and other species.

The influence of the following conditions upon the digestible protein and digestible energy value of forages was examined: (1) Cutting time (and growth stage) (Delaware, Maryland, New Hampshire, New York, Pennsylvania, Rhode Island, West Virginia and Vermont), (2) nitrogen fertilization (Maine, New Hampshire, New Jersey and New York), (3) irrigation (New York), (4) level of intake (New York), (5) species of plant and (6) weather damage.

Data obtained during the year support those obtained previously in this project demonstrating that the nutritive value of first cuttings declines rapidly as plant growth approaches maturity. Studies in progress will help determine to what extent the relationship between the cutting time and the digestible energy value varies within the region.

Although nitrogen fertilization has effected an increase in the digestible protein content of grasses at all stations where it has been examined, the effect upon the digestible energy value has been variable. Nitrogen fertilization of first-growth brome grass (New Hampshire) and timothy aftermath (Maine) at levels up to 200 lbs./acre and of first-growth timothy and second-, third-, and fourth-cuttings of orchard grass at levels of 50 and 150 lbs./acre, respectively, (New York) had no effect upon the digestible energy value. However, moderate increases in the digestible energy value of reed canary grass and orchard grass aftermaths resulted from the application of 200 lbs./acre (New Jersey). Though it increased the yield, irrigation of the third growth of DuPuits alfalfa at two locations did not affect the digestible energy value (New York). Different from the situation with mixed rations of forages and concentrates, the proportion of the energy digested in all-forage rations was not affected by the level of intake (New York).

The yield of digestible dry matter per unit of land as determined in cow-grazing trials (Delaware), the lactation response of cows fed hays (Maryland, Massachusetts and Vermont), and the growth response of lambs fed hays (New Jersey) are additional criteria of nutritive quality being employed in the region. The results obtained to date in those experiments (Maryland and Vermont) in which the time of cutting is the major variable studied show a positive correlation between the milk-production response and the digestible energy value of forage. The ad libitum intake of forages by cows in the production trials appears to be highly related to nutritive value.

Considerable attention was given during the year to the study of means of developing chemical and biological indices of forage quality. The approaches taken include: (1) The study of a chemical-digestion method (New Jersey), (2) in vitro fermentation indices (New Jersey, West Virginia), (3) the rate of development of ruminal papillae in calves as a measure of

forage quality (Vermont), (4) use of the rabbit as an assay animal (Delaware), (5) use of acid-insoluble lignin as a predictor of nutritive quality (U. S. Regional Pasture Research Laboratory), and (6) use of the leaf and dry matter contents as predictors of nutritive value (New York).

The joint effort of four stations (Pennsylvania, Maryland, Massachusetts, and New Hampshire) to compare the digestibility of the dry matter, protein and energy of given lots of forage as determined with both sheep and cattle has been completed and the data are being processed for publication. The data obtained demonstrate that digestion coefficients measured with sheep or cattle are interchangeably applicable to the other of these two species. Further studies indicated that the digestible energy value of forages for rabbits, though lower than those for sheep, may have predictive value (Delaware). Additional comparisons between wethers and heifers as experimental animals for use in digestion trials are in progress (Maine).

USEFULNESS OF FINDINGS:

The results of the studies made as a part of this project will (a) contribute ultimately to the knowledge of the conditions which influence the nutritive characteristics of forages, (b) provide basis for the selection and management of species and varieties having high nutritive yield which are best adapted to the region and/or segments of the region and (c) provide a basis for the formulation of livestock rations under practical farm conditions.

Results of the work carried on dealing with the nitrogen fertilization of grasses have shown that nitrogen fertilization will increase effectively the digestible protein value of forage and result in higher yields of digestible protein and digestible energy.

Finding a simple test for predicting nutritive value will allow faster progress to be made in forage breeding and management research much less expensively than is now possible. Progress of a promising nature has been made towards this objective.

Results of the sheep-cattle digestibility comparisons show that the data obtained with sheep apply also to cattle. This means that by using sheep, forage from small plots (such as those commonly used in agronomic research) can be employed in digestion trials and the cost of experimentation can be reduced considerably.

The data accumulating at all cooperating stations continue to demonstrate the high inter-predictability of the digestible energy and TDN values of forages.

WORK PLANNED FOR NEXT YEAR:

A revised project outline will be submitted.

The nature of the work accomplished during the last three years makes it desirable that the major objectives of the original project be retained in the revised project under which the work planned for next year will be conducted. During the next year greater emphasis will be given to: (1) Quantifying the relationship between the time of cutting and the digestible energy value (Delaware, Maine, Maryland, New Hampshire, New York, Pennsylvania and Vermont). Particular attention will be given to the effects of climatic and geographic conditions within the region and within the states of New Hampshire, New York and Vermont. (2) Developing in vitro fermentation and chemical criteria as indices of nutritive quality (Massachusetts, New Jersey, New York, West Virginia, U. S. Regional Pasture Research Laboratory, and the Dairy Cattle Research Branch).

Other studies will involve the effects of nitrogen fertilization upon the nutritive value of grasses (Delaware, Maine, Maryland, New Hampshire, New Jersey, New York, and Rhode Island), the nutritive evaluation of silages (New Jersey) and the use of rabbits as test animals for the evaluation of forages (Delaware, Maine, New Hampshire).

Studies of the milk-production response of cows fed forages of various species harvested at different stages of growth will be continued by two stations (Maryland and Vermont).

Continued emphasis will be given to the use of single-species stands in all studies itemized above.

Title: PROJECT NE-28 - BREEDING AND EVALUATION OF IMPROVED VARIETIES OF FORAGE CROPS ADAPTED TO THE NORTHEAST

Leader: C. C. Lowe, Chairman, Regional Technical Committee

Cooperators: Connecticut (Storrs), Maine, Maryland, New Hampshire, New Jersey, New York (Cornell), Pennsylvania, Rhode Island, Vermont, and West Virginia Agricultural Experiment Stations, the U. S. Regional Pasture Research Laboratory, the Crops Research Division, the State Experiment Station Division, A.R.S., U.S.D.A., and the American Seed Trade Association

Phases of breeding research on the listed species were carried on by the following cooperating state experiment stations during 1958: Orchardgrass - New York, Pennsylvania, Maryland; smooth brome grass - New Hampshire, New York, Pennsylvania; timothy - New York, Maine, Pennsylvania; alfalfa - Maine, Connecticut, Rhode Island, New York, Pennsylvania, New Jersey, West Virginia; birdsfoot trefoil - Vermont, New York, Pennsylvania, New Jersey; Ladino clover - New Hampshire, Maryland.

Breeding materials of the above listed species which were selected within the Northeast are being evaluated for regional adaptation and performance. These materials include clones, their polycross-progeny and some experimental synthetic varieties. Selection is based on improvement of both quality and quantity of forage produced by these species. Regional evaluation of these materials is in different stages of advancement due to different evaluation requirements and time of initiation of the separate phases of work.

Orchardgrass. The best clones selected within the region prior to 1954 have now been clonally and progeny evaluated for three or more years at three locations. Seven experimental synthetics have been constituted on the basis of this information. The results appear promising for producing varieties which are more easily managed and have higher forage quality on given harvest dates due to their later maturity than Common orchardgrass.

Brome grass. Clonal and progeny evaluation of the region's best clones has been completed at three locations. Experimental synthetics are being constituted to improve upon such specific attributes as growth habit, production distribution, leafiness and disease resistance. Some of the synthetics which have been tested are markedly superior for one or more attributes to varieties in current usage.

Alfalfa. Evaluation of clones, progenies and synthetics was continued at six locations. Some of the clones tested show good promise on the basis of incomplete results for ultimate use as parents of superior varieties for both restricted and wide areas of adaptation. Additional trials were established in 1958.

Timothy. Clonal nurseries and polycross progeny trials for clones of different maturity groups were established successfully during 1958. Evaluation will begin for yield and other characters in 1959.

Ladino Clover. First year yield information was obtained on polycross progenies at three locations and varieties and synthetics at six locations during 1958.

Birdsfoot Trefoil. Polycross progeny and variety and synthetic trials of birdsfoot trefoil were continued during 1958. None of the selections tested to date appeared superior to currently available varieties. Further breeding and selection will be needed in this species.

USEFULNESS OF FINDINGS:

The limits of adaptation and use for new varieties of brome grass, orchardgrass, alfalfa and birdsfoot trefoil have been more clearly defined by comprehensive regional evaluation under Project NE-28.

The information which has been and will be obtained from research conducted under the project on breeding materials developed within the region has already influenced the direction and emphasis of work on the various species at both local and regional levels.

The project has given valuable evidence on the usefulness of certain currently used breeding techniques and has demonstrated the workability of a regional approach to forage crop breeding.

Insufficient time has elapsed to produce regionally adapted varieties constituted primarily on the basis of this project's results. However, this application will be made and the prospects for evolving successful new varieties appear to be good for brome grass, orchardgrass and alfalfa.

WORK PLANNED FOR NEXT YEAR:

Project NE-28 expires on June 30, 1959. Contingent on project revision, evaluation of breeding materials now in progress on alfalfa, Ladino clover and timothy will continue and experimental synthetics and hybrids will be constituted and comprehensively evaluated for brome grass, orchardgrass and alfalfa. New breeding materials on brome grass and orchardgrass would also be clonally and progeny evaluated. Further information on the applicability of currently used breeding techniques for forage crops will be a major objective in the work.

Title: PROJECT NE-29 - ESTABLISHMENT AND MANAGEMENT OF PERENNIAL FORAGE SPECIES AND VARIETIES FOR PERSISTENT PRODUCTION IN THE NORTHEAST.
 SUB-PROJECT I - SEEDLING ESTABLISHMENT AND EARLY DEVELOPMENT OF FORAGE GRASSES AND LEGUMES AS AFFECTED BY CULTURAL TREATMENT.
 SUB-PROJECT II - PERSISTENCE, PRODUCTIVITY AND GROSS NUTRIENT VALUE OF PERENNIAL FORAGE CROPS AS INFLUENCED BY MANAGEMENT PRACTICES.

Leader: J. B. Washko, Chairman, Regional Technical Committee

Cooperators: Connecticut (Storrs), Maryland, New Jersey, New York (Cornell), Pennsylvania, Rhode Island, Vermont and West Virginia Agricultural Experiment Stations, the U. S. Regional Pasture Research Laboratory, the Crops Research Division, the Agricultural Engineering Research Division, and the State Experiment Station Division, A.R.S., U.S.D.A.

PROGRESS OF THE WORK AND PRINCIPAL ACCOMPLISHMENTS:

Four experiments designed to accomplish the following primary objectives were initiated under this regional project in the spring of 1954: (1) to determine the effect of various methods of seeding and of fertilizer application and placement on the establishment and early development of forage crop seedings, (2) to evaluate the effect of different cropping and clipping practices on establishment, early development and winter survival of six forage species seeded with and without a companion crop, (3) to investigate the interrelationship of species, cultural practices and climatic factors as they influence seedling establishment, (4) to study the influence of seeding methods and management practices on yield, composition and persistence of forage crop seedings; (5) to develop techniques and practices which would lead to more effective, reliable and economical forage crop establishment and production, and (6) to record monthly the microclimatic factors of air temperature, humidity, radiation, soil moisture and temperature as they influence all seeded experiments.

Field activities in 1958 consisted of collecting and evaluating the final year's experimental data on three of the four experiments still in progress. Throughout the region the 1958 climatic conditions were most favorable for forage production in contrast to the droughty year of 1957. This was reflected in forage yields which were the highest recorded since the project was initiated.

For example, alfalfa-bromegrass, birdsfoot trefoil-timothy and Ladino clover-orchardgrass were harvested from 2 to 5 times and produced from 2.5 tons to 7.1 tons of dry forage per acre depending upon association and location within the region.

While variations in management treatment effects occurred from one Experiment Station to another and from year to year, pertinent results from each phase of these investigations are summarized as follows:

Sub-project I - Seedling Establishment. Data from the 6 Experiment Stations, Connecticut, Maryland, New Jersey, New York, Pennsylvania, and Vermont working on this phase indicate the following: (1) The most successful management practice favoring stand establishment and subsequent productivity of two forage associations, namely alfalfa-bromegrass and Ladino clover-orchardgrass, was the complete elimination of weed competition during the seeding year. This was manifested in hand weeded plots by better plant development as measured in terms of higher crown weights and more tillers per plant in the fall of the establishment year and forage yields the following year that ranged from .5 to 1.0 ton higher than where weed control was achieved by clipping. (2) When seeded in the absence of companion crops, weed control is essential to proper establishment of forage species. Poorest establishment of all species was obtained when weeds were left unclipped for the following three legume-grass associations; alfalfa bromegrass, birdsfoot trefoil-timothy and Ladino clover-orchardgrass. (3) Where weeds are to be controlled by mowing one clipping per season appears to be more beneficial to plant development than two or more clippings. More than one clipping during the establishment year restricts plant development that year and reduced forage yields in the harvest year. Such severe clipping treatments were found to be particularly detrimental to bromegrass and orchardgrass establishment. (4) If forage crop seedings are made with companion crops the young seedlings of the forage species encounter severe competition from such companion crops, particularly, in droughty years. Whether this results in reduced forage production or not in the first harvest year appears to be determined by weediness of the field site. When weeds are a serious problem they offer greater competition to young seedlings than does the companion crop. (5) Forage species differ in their capacity to withstand competition from a companion crop. Alfalfa and birdsfoot trefoil yields were generally reduced but Ladino clover yields were favored by a companion crop. Establishment of the grasses bromegrass, orchard and timothy was poorer with companion crops than without. (6) Competition from an oat companion crop to a forage crop seeding can be minimized by removal of the oats at the silage stage (as heads emerge from the boot). If removed for grain, leaving a 2-inch oat stubble was less harmful to forage seeding survival than leaving a 6-inch stubble.

Sub-project II - Alfalfa and Ladino Clover Harvest Management. There appear to be two critical periods in the seasonal development of alfalfa during which harvesting is harmful to persistence of stands. One is in the spring prior to the full bud stage and the other is the late summer period extending from the last week of August in the northern part of the region to late September in the southern part. From the standpoint of highest production with good quality forage the 1/10 bloom stage was best for removal of the first harvest in the three states, Maryland, Rhode Island and West Virginia. The full bud stage of harvest was as good as the 1/10 bloom stage in the first three out of the four years but stands thinned more rapidly in the fourth year under this cutting management treatment than harvests made at 1/10 bloom or later. However, forage harvested at the bud stage was found to be superior in feeding quality to that of the 1/10 bloom stage at both Maryland and Rhode Island. Fall cutting management treatments appear to be

more critical with respect to stand persistence in those states with long growing seasons whereas the reverse appears true for those with shorter growing seasons. Late fall forage removal (after average date for killing frost) was least harmful to stand maintenance of the early, middle, and late fall cutting treatments.

Ladino clover stands were eliminated by the severe drought of 1957 at two of the three stations, New York and Rhode Island, and so seriously reduced at West Virginia as to make interpretation of management treatments difficult.

Other Activities. Data from the four experiments have been transferred to IBM cards and programs have been written for local and regional analysis of the collected data. The first drafts of two regional publications are nearing completion, one on merits of band versus broadcast seeding under different fertility levels, and the other on the microclimate of the region in relation to the seedling establishment experiments. Data are now being processed for three additional publications, one on the use of differential clipping management treatments to minimize competition from weeds and companion crops and the other two on alfalfa and Ladino clover management, respectively.

A Regional Project entitled "The Effect of Cutting and Management Treatments on Productivity and Persistence of Perennial Grasses", has been drafted to succeed NE-29 and is being submitted for consideration by the Northeast Experiment Station Directors.

USEFULNESS OF FINDINGS:

These investigations are yielding basic information on the factors that govern the establishment, production and persistence of several of the more important forage species within the region. The seeding establishment experiments are providing invaluable information on the factors which govern successful stand establishment of forage crops. These experiments have re-emphasized the serious nature of the competition offered young forage seedlings by weeds and companion crops and the means by which it can be minimized. The information derived, when interpreted in relation to the soil and climatic conditions collected within the various states will provide guidance for the development of sound seeding recommendations for the forage crops required to feed Northeast livestock. Since establishment costs for forage crops range from \$35 to over \$50 per acre the development of superior seeding techniques will not only help insure this cash investment for farmers but provide handsome dividends as well in the form of quality pasturage, silage and hay for their livestock.

Many of the principles upon which forage management practices are based today were developed with varieties having lower production potentials than are in existence today. If farmers are to realize maximum benefits from the superior forage crop varieties available to them at present some of these principles and practices are in need of re-evaluation. For example, alfalfa harvesting has moved from a 2- and 3-cut harvest system to a 3- and 4-cut system in the Northeast, depending upon length of growing season.

Results from the alfalfa management experiment indicate that the critical factor determining stand longevity under this multiple cut system is time of removal of the 3rd and 4th cutting.

Therefore, this regional research is providing valuable information that can be used as the basis for sound management of approximately 25 million acres of grassland found within the Northeast Region.

WORK PLANNED FOR NEXT YEAR:

The five planned regional publications previously mentioned will be published as rapidly as the data are analyzed statistically and interpreted. Field seedings of the grasses will be made during 1959 at the various participating Stations in the Region according to plan if the New Regional Project is approved.

PASTURE RESEARCH AT STATE STATIONS

CONNECTICUT (STORRS)

Title: ALFALFA EXPERIMENTS

Leaders: B. A. Brown, R. A. Peters and E. J. Rubins

(a) Fertilization (G3): On a soil that initially had a "medium" amount of available P, the stands and yields in the fourth and last harvest season (1958) were the same where superphosphate (46%) had been either banded or broadcast and disked in at from 90 to 720 pounds per acre before seeding in 1954. The 4-year averages did not differ either.

Although there was very marked seedling response to the banded superphosphate, the later results indicate that no unfavorable effects may be expected, regardless of placement, from the omission of P carriers for several years.

In direct contrast to superphosphate, banded muriate of potash at 200 and 400 pounds per acre had harmful effects on seedling establishment of alfalfa but, regardless of placement, had very marked beneficial influences on both stands and yields during 1955 when no potash was added and from 1956-1958 when 180 pounds per acre of K_2O were applied annually.

The banding of limestone (up to 1000 pounds per acre) on this soil with a pre-treatment pH of 6.0 was of no benefit in the establishment of alfalfa but had, like potash above, important influences on subsequent stands and

yields. For example, the alfalfa stands and yields of total dry matter in 1958 averaged as follows for three placements of limestone:

Limestone in 1954 (lbs./A)	0	500	1000	2000	4000	8000
Alfalfa Stands 1958 (%)	43	42	35	50	55	63
Total Dry Matter 1958 (cwts./A)	49	51	50	54	61	65

Field G15: In the fourth harvest year (1958) under 7 cutting systems, Rhizoma alfalfa plus timothy, yielded as much with 180 pounds per acre of K_2O annually as with 270 pounds. Nitrogen (N) at 180 pounds per acre annually did not increase the yields of the first cuttings but stimulated about 30 percent more growth in the second and third crops.

With an approximately 50 percent stand of legume, a 4-year old seeding of Rhizoma alfalfa and timothy produced 1300 pounds (20 percent) more dry matter in 1958 when 80 pounds per acre of N were applied for each of the three cuttings.

With a Buffalo alfalfa-timothy seeding where less legume was present than in the Rhizoma seeding, the average gain for 240 pounds of N was 2100 pounds of dry matter or about 9 pounds for each pound of N.

Field W22: In the second harvest year (1958) there were no benefits from banding either superphosphate (46 percent) at 200 pounds or superphosphate at 200 plus muriate of potash (60 percent) at 100 in addition to liberal, disked in fertilization before seeding DuPuits, Narragansett and Vernal alfalfa in 1956. These results are similar to those with Buffalo alfalfa on G3.

Field W11: In a third plot experiment in 1958, the banding of superphosphate (46 percent) at 200 pounds per acre on liberally fertilized land increased the height of three varieties of alfalfa six weeks after seeding by 30 percent. The banded superphosphate was not effective when the seed was broadcast. Again, banding KCl (60 percent) at 100 pounds per acre with the superphosphate was not beneficial to the seedlings.

The inclusion of either 3 or 6 pounds per acre of timothy reduced the seedling growth of all three varieties of alfalfa.

(b) Varieties: In the seventh harvest season (1958), as in the previous year, only one (C180) of the 16 unnamed strains had a poorer stand or smaller yield than Buffalo and Ranger, the best of the 14 named varieties. The five with the best stands and highest yields were C191, C188, C187, C130 and C190. The five with the best 7-year averages were: C130, C223, C188, C183 and C57. The five poorest in 1958 were C180, C54, C199, C197 and C79.

The 7-year average yields, including grasses and weeds, of DuPuits and Narragansett were only two-thirds those obtained from the five best unnamed strains.

(c) Management (G15N): A Rhizoma-timothy seeding of 1954 has been cut by seven different systems for four years. Four fertilizer treatments were tested with each cutting system, but had little effect. Using the average yields of all fertilizer treatments, the four systems with four cuttings per season yielded 53 cwts. per acre of dry matter in 1958 while the three systems with three cuttings per season yielded 66 cwts. The alfalfa stands of the three-cutting group were much better also.

Field G8C: During September and October 1957, quadruplicated plots of Buffalo, DuPuits and Vernal alfalfas, seeded in 1956 and all mowed on 6/13 and 8/3, 1957 were given the following five fall cutting treatments: (1) no fall cut; (2) cut 9/16; (3) cut 9/30; (4) cut 10/14; and (5) cut 10/28. The stands and yields of all of the varieties were reduced in 1958 by all of the fall cuttings of 1957. By far, the greatest reductions in yields occurred in the first cutting of 1958. In comparison with the "no-cut" plots, these percentages were as follows:

Fall Cuts 1957:	9/16	9/30	10/14	10/28
% Reductions: Buffalo	40	47	30	11
DuPuits	20	26	11	3
Vernal	9	21	18	9

With each variety, the 9/30 cutting was the most harmful. In similar experiments with Grimm and Variegated about twenty years ago, mowing in mid-September was more injurious than harvesting in late September. However, the data substantiate the earlier conclusion, namely, that in Connecticut, alfalfa should not be cut in September and early October. Since late October harvests are small and poor in quality, it is doubtful if any fall cuttings should be made after early September.

Ladino Clover Longevity: In the 18th year after seeding (1956), Ladino clover had good (about 50 percent) stands on the plots cut four times per season with an ordinary tractor mower since 1950. The very dry season of 1957 (worst in seventy years from April 10 to August 20) eliminated practically all of the Ladino clover. No appreciable come-back was noted during the rather wet season of 1958. Thus, it appears that drought was more effective in eliminating Ladino clover than any of the ten former cutting management systems, the competition of either orchardgrass or Kentucky bluegrass and the application of large amounts of fertilizer nitrogen.

The mowed section (150' x 150') of this experiment is being kept untilled for further observations on the effects of frost-crack seeding, fertilizers, and cutting management on the reestablishment of Ladino clover.

The two sections grazed since 1954 were grazed again in 1958. There was scarcely any Ladino clover on either paddock. Since this part of the experiment will not be continued in 1959, the averages of the five years are given below:

<u>Nitrogen Added</u>	<u>Heifer Days</u>	<u>Pounds Gained</u>
0	130	205
+	157	144

Ladino Clover Response to Heavy Liming: In a greenhouse pot experiment to test the efficiencies of various carriers of K, the most outstanding result was a 55 percent greater yield from eight cuttings of the Ladino clover component, seeded with orchardgrass, on soil limed to pH 7.6 than to pH 6.9.

Trefoil Management: In the third season of differential grazing, yearling dairy heifers had nearly twice as many days of grazing and over twice as many pounds of gains on the pastures grazed when the herbage was 10 inches tall than when 6 inches tall.

Title: RESPONSE OF ESTABLISHED BIRDSFOOT TREFOIL AND ALFALFA PLUS LADINO CLOVER TO APPLICATIONS OF POTASSIUM GIBERELLATE

Leader: R. A. Peters

Applications of potassium giberellate were made following the second cutting of a stand of alfalfa, birdsfoot trefoil and Ladino clover in the second year of growth. Regrowth had started at the time of treatment with the alfalfa, trefoil and clover measuring 3-4, 2-3, and 4-6 inches tall, respectively. Rates of 250 and 1000 p.p.m. of giberellate in 40 gallons of water per acre were applied on September 12, 1958.

The response to treatment was most noticeable with the trefoil with a several hundred-fold increase in dry matter obtained from samples cut October 31, 1958. Treated trefoil continued to grow despite the lateness of the season with the non-treated trefoil showing very little tendency toward further growth.

There was less increase in the dry matter of the alfalfa; however, the dry matter was doubled.

Ladino clover showed little response to treatment in contrast to previous greenhouse tests. This has been attributed in part to the more advanced stage of the Ladino clover's regrowth at the time of treatment.

Title: PASTURE RENOVATION USING CHEMICALS**Leader: R. A. Peters**

A typical "native pasture", too rocky to till, was sprayed in September 1957 with 10 pounds of Dalapon (active) per acre plus 5 pounds of amitrol (active) per acre. The vegetation was primarily Agrostis, Danthonia and perennial herbs. The amitrol was used to control the herbaceous perennials which become prolific if only the grasses are killed.

On April 18, 1958, the area was limed and fertilized and Ladino clover and birdsfoot trefoil broadcast on the dead sod. Conditions for germination were excellent and a good stand of Ladino clover and a fair stand of birds-foot trefoil were obtained.

Annual weeds were starting to offer competition by June so the area was sprayed with 3 pounds (active) of 2,4-DB.

By mid-summer an excellent cover of Ladino clover had been obtained which could have been readily grazed. The birdsfoot trefoil stand persisted but did not make much growth the seedling year. Recovery of the perennial weeds and grasses was becoming evident by the end of the season.

The stands obtained in 1958 were the best obtained in several trials. This was attributed to better control of existing vegetation and to the cool, moist 1958 season which was favorable for a frost-crack seeding.

Title: EFFECTS ON OATS OF SEVERAL HERBICIDES APPLIED ON UNDER-SEEDED LEGUMES**Leaders: Robert A. Peters and Warren E. Wells**

A field evaluation during the 1958 growing season was made of several herbicides of potential value for weed control on under-seeded legumes. The chemicals were applied when the small grain was in the late tillering stage. Notes were taken as the crop developed and the yields and bushel weight determined by threshing the mature grain.

Reductions in yields of threshed oats and of bushel weight followed the application of 2,4-DB ester at 1+2 pounds per acre in the late tillering stage. Much less injury was obtained from 2,4-D amine or 2,4-DB amine. When Dalapon at 1-1/2 pounds was used alone or with 2,4-D amine or 2,4-D, damage was also severe; a direct indication of injury from the higher rate of Dalapon.

Title: YIELDS OF SILAGE CORN AS RELATED TO THE USE OF SEVERAL HERBICIDES

Leaders: Robert A. Peters and Warren E. Wells

Thirteen herbicides each at two rates were applied on silage corn heavily infested with weeds, particularly wild mustard, at two stages of growth. Applications were made the day after planting and as the corn was emerging from the soil 5 days after planting. In one treatment plots were kept weed-free.

The highest yields of silage corn were obtained from simazine (2-chloro-4,6-bis (ethylamino)-s-triazine), DNBP (dinitro-o-sec-butylphenol, alkanolamine salt) and combinations of the latter with Dalapon (dichloropropionic acid, sodium salt). The former was applied both pre-emergence and at emergence while the DNBP treatments were applied at emergence only.

Injury to the corn was noted when using 2 pounds per acre of diuron (3,(3,4-dichlorophenyl)-1-dimethyl urea) applied at emergence and from TCB (2,3,6-trichlorobenzoic acid) at 3 pounds per acre applied at emergence.

The simazine treatments were superior to the other treatments in depressing weed growth for the entire growing season.

Title: YIELDS OF LEGUME-FORAGE GRASS MIXTURES AS AFFECTED BY SEVERAL HERBICIDES APPLIED ALONE AND IN COMBINATION DURING ESTABLISHMENT

Leaders: Robert A. Peters and Warren E. Wells

Selective weed control in pure legume seedings is now feasible with available materials. Forage grasses are usually seeded with legumes in the Northeast, however, making selective removal of both grassy and broadleaf weeds from the mixed stand difficult.

Several chemicals, alone and in combinations, were evaluated in greenhouse and field experiments during the 1958 season on forages in the early seedling stage.

For the alfalfa-smooth brome grass, neburon (3-(3,4-dichlorophenyl)-1-methyl-1-N-butylurea) was the most promising treatment in terms of weed control and yield of forage. Dalapon (dichloropropionic acid, sodium salt) plus 2,4-DB (2,4-dichlorophenoxybutyric acid, amine salt) gave promising results in the greenhouse but some injury to alfalfa at the rates used in the field test.

On the birdsfoot trefoil-timothy mixture the Dalapon-2,4DB treatments were the most promising in both the greenhouse and the field. Neburon was generally more toxic to trefoil, especially in combinations with other chemicals, than on alfalfa.

Ladino clover-orchardgrass growth was at a maximum when low rates of Dalapon and 2,4-DB were used. Diuron (3-(3,4-dichlorophenyl)-1,1-dimethylurea) was notably toxic to Ladino clover.

Title: COMBINATIONS OF CHEMICALS FOR WEED CONTROL IN NEW ALFALFA SEEDINGS

Leaders: Robert A. Peters and Albert J. Kerkin

A spring seeding of alfalfa at the Agronomy Research Farm was treated in the early seedling stage to evaluate the value of combined chemical treatments for selective control of both grassy and broadleaf weeds.

The May 23 seeding was cut for hay yield determination on August 13, 1958. A neburon-dalapon (4 + 1/2, and 4 and 1) combination treatment resulted in the best yield, the latter treatment giving over 1 ton of dry matter per acre as compared to 1/4 ton from the untreated check. This treatment gave both grassy and broadleaf weed control including control of both common chickweed and white cockle.

The 2,4-DB and Dalapon combination (2 and 1) was not as satisfactory in this experiment as in some others. This was attributed to a typically heavy growth of grassy weeds and chickweed.

DELAWARE

Title: IRRIGATION AND NITROGEN FERTILIZATION OF LADINO CLOVER, ALFALFA, BIRDSFOOT TREFOIL AND ORCHARDGRASS

Leader: W. H. Mitchell

This study involves the application of 0, 1", 2" and 4" of water when moisture is reduced to about 1/2 the available water holding capacity at depths of 6", 12" and 24". Nitrogen levels are 0 and 150 pounds per season applied as ammonium nitrate in 50-pound increments.

Data have been collected for 2 years, 1957 with below average rainfall and 1958 with above average rainfall. Due to the high rainfall in 1958 irrigation was not applied. Response to irrigation in 1957 was generally large for all species except birdsfoot trefoil. In the trefoil plots irrigation encouraged the growth of weedy grasses, particularly Fall Panicum (Panicum dichotomiflorum). The lowest yields of trefoil occurred under irrigation and nitrogen treatments.

There were no significant differences in yield between irrigation at the 6", 12" and 24" depths. With the advent of rain following the prolonged drought of 1957 all species not under irrigation made more growth than where irrigated during the drought.

Ladino clover stands were severely infested with the crown rot disease during the winter of 1957. The most severe injury was associated with the no-irrigation treatments, the least injury in the border strips, and intermediate injury in the irrigated plots. The no-irrigation plots made a heavy growth during the previous September and October which may have encouraged infection by the organism at that time.

Reseeding of Ladino clover was greater in the no-irrigation plots which tended to compensate for the greater crown rot injury to these plots.

Following the second harvest in 1958 the regrowth of orchardgrass under the nitrogen treatment was slow and after a period of 2-3 weeks over 80 percent of the plants were dead. Root samples taken to a depth of 24" showed that root growth as measured by dry weight and absorption of methylene blue was less under the nitrogen treatment than where no nitrogen was applied.

Sugar analyses made of the leaf bases following the second harvest showed a higher level of total carbohydrates in the no-nitrogen plots than in the nitrogen plots.

Title: NITROGEN AND PHOSPHORUS FERTILIZATION OF ALFALFA-GRASS MIXTURES

Leader: W. H. Mitchell

The principal objective of this study is to determine to what extent phosphorus requirements can be met by applications at seeding time. Mixtures consist of alfalfa grown with brome grass, orchardgrass, tall fescue, timothy, and reed canarygrass. All mixtures received 500 pounds of 20% superphosphate at seeding time. All mixtures with the exception of alfalfa and brome grass were band seeded.

Following establishment all plots received 200 pounds of K_2O and 20 pounds of borax annually. In a split plot design nitrogen and phosphorus treatments consisting of 0, 50, 100 and 200 pounds of each were made annually in March.

At the end of 2 years no significant yield increases have been noted from the use of either the additional nitrogen or phosphorus.

The first cutting samples from the alfalfa-bromegrass and alfalfa-orchard-grass plots were analyzed for phosphorus in 1958. Although the use of additional phosphorus has not resulted in higher yields it has resulted in higher phosphorus levels in the plants.

<u>Annual Phosphorus Treatment Lbs. per Acre of 20% Super- phosphate</u>	<u>Average Percent Phosphorus in Plant Tissue</u>
0	.188
250	.220
500	.232
1000	.243

Title: A COMPARISON OF ROW AND BROADCAST PLANTINGS OF GRASS-LEGUME MIXTURES

Leader: W. H. Mitchell

The botanical composition of grass-legume stands resulting from a broadcast seeding of the seed mixture is difficult to predict. Race horse owners are rather specific as to the percentage of grass and legumes in the hay which they buy. This means that in many cases they buy what is available rather than what they really want.

It seems possible that certain advantages, such as greater control over the balance of grass and legumes in the forage, less above ground competition between species, and a lower incidence of certain forage diseases, might result from putting species in separate rows.

Separate studies are being carried on using alfalfa-orchardgrass and red clover-timothy mixtures. Seeding methods include broadcast, components mixed in 8-inch rows, and the grass-legume components planted in alternate 8-inch rows. Nitrogen, from urea, was applied in a split plot design at 0, 50, and 100-pound levels.

Title: ACCEPTABILITY OF HEAT CURED HAY MIXTURES BY THOROUGHBRED HORSES

Leader: W. H. Mitchell

From the standpoint of hay producers as well as hay buyers it is important that there be some understanding of the hay eating habits of race horses. Traditionally horses have been fed a hay mixture consisting of red clover and timothy. Although much variation has existed among horsemen, generally the mixture has been relatively high in red clover for mares, colts, and for feeding during the non-racing season. During training and actual racing periods the mixture consisted of relatively more timothy. Alfalfa has generally been considered suitable only for mares, colts and non-racing feeding and then only in limited quantities.

In the course of a survey of over 50 leading racing stables it became apparent that many leading horsemen were breaking with tradition. Mixtures containing a large amount of red clover and in some cases consisting wholly of red clover were being fed at leading stables. Alfalfa mixtures were being used and in some instances were fed exclusively to horses while training and racing.

This rather confusing picture of hay feeding practices with race horses led to a series of feeding tests designed to measure a horse's preference for different hay mixtures. The preference of one hay mixture over another does not necessarily signify that one is more valuable or nutritious than the other but if preferences should coincide with low production costs, higher amounts of minerals and protein or other known factors of quality, this information should prove of value to producer, buyer and feeder.

Feeding tests were conducted on a "cafeteria basis" using hay nets -- each net having a capacity of about 25 pounds. The number of nets placed in a stall was determined by the number of different hay mixtures being compared. The nets were filled, weighed and hung at random locations on the walls of each stall. The total amount of hay available daily to any one horse varied with the type of test being conducted but generally it was between 50 and 100 pounds. The nets were reweighed in approximately 24 hours -- the difference representing the pounds of hay consumed. Animals were selected at random with the result that the tests were conducted with a wide variety of horses. The test groups represented horses on pasture, horses on barn feeding only, mature animals, yearlings, horses in training, horses actively racing and disabled horses.

Feeding tests have been conducted over a period of several months. There has been no evidence of digestive disturbances resulting from feeding any of the different hay mixtures either in the form of baled hay or pelleted hay. There are indications that quality is more important than mixtures in determining the level of hay acceptance. Alfalfa-tall fescue, for example, had a higher acceptance than red clover-timothy, the latter being cut at the late bloom stage and the alfalfa-fescue being cut at the early bloom stage.

When 4 mixtures were compared simultaneously, one mixture would generally have a higher acceptance than the others. If this mixture was then removed from the test the second choice mixture became first choice and the total amount of hay consumed remained essentially the same.

Timothy hay cut at vegetative, boot, and full bloom stages was fed in acceptance tests. Acceptance was in the order of maturity with a great difference in favor of the vegetative and boot stages of growth.

Red clover hay pellets, 3/4" in diameter and approximately 1" long compared favorably with the same hay in baled form in preliminary acceptance tests. In all cases pelleted hay was accepted in larger amounts than baled hay. It seems significant that at least 25 percent of the total consumption was from baled hay even though the preference was for pellets.

A pellet mill has been installed and this work will be continued.

MAINE

Title: FORAGE BREEDING AND VARIETY TESTING

Leader: C. R. Blackmon

Red Clover: During 1958 the following medium red clover varieties were tested at Orono and Presque Isle: Kenland, Wisconsin Synthetic, Purdue, Altaswede, Reinholdt, Pennscott, Alaskaland, R-11, Dollard and Chesapeake. Dollard and Wisconsin Synthetic have given the highest forage yields and maintained better stands over a longer period of time than the other varieties. This may be due to their greater resistance to mildew and northern anthracnose.

Observational Nursery: A nursery is being maintained to give preliminary evaluation of new varieties, selections and plant introductions to determine if they are sufficiently adapted to be entered into the advanced variety testing program. This nursery is composed mainly of timothy, brome grass, orchard grass, red clover, and alfalfa varieties. Forty-two Swedish red clover strains were added to this nursery in 1958.

Domestic Exploration: This phase of the program should develop considerably in 1959 since many old red clover and alfalfa fields have been located throughout Maine. Superior clones may be selected for future breeding work.

Title: TIME AND RATE OF NITROGEN ON GRASS

Leaders: C. S. Brown and P. N. Carpenter

The field experiments begun in 1954 (1954 Annual Report, page 29) were terminated in the fall 1958. No nitrogen was applied in 1958. Three harvests were made to determine the residual effects of the previous three years of intensive nitrogen fertilization. Precipitation was well-distributed throughout the season. Check plots of Ladino clover in association with each grass exhibited excellent growth.

Uptake of nitrogen by the three grasses ranged from 20 pounds N in the 0 N treatment to 74 pounds N in the 360 N treatment. Nearly all of the residual nitrogen was recovered in the first cutting. Check plots of Ladino clover yielded 175 pounds N.

Title: RATE OF NITROGEN, PHOSPHORUS, AND POTASSIUM ON TIMOTHY

Leaders: C. S. Brown and P. N. Carpenter

The study reported in the 1957 Annual Report, page 51, was continued for the third year. As in 1957, potassium deficiency was severe at the 200 and 300 N level when only 50 pounds K_2O were applied. The use of 150 pounds of K_2O increased dry matter yields at the 200 N level by 0.7 on one soil and 0.3 ton on the other. Little further increase resulted with 300 pounds K_2O . Phosphorus at the rate of 50 pounds P_{2O_5} proved adequate at the 200 N level. At 300 N, additional phosphorus increased yields 0.2 ton on both soils.

Title: POTASSIUM SUPPLYING POWER OF MAINE SOILS

Leaders: C. S. Brown and P. N. Carpenter

A greenhouse study was initiated in the fall 1957 to determine the range in potassium supplying power of major soil types within the state. Ladino clover was used as the test crop. Seven harvests were made.

Preliminary data suggest that soils high in clay content or derived from micaceous parent material are appreciably higher in their release of native soil potassium. A further test of this is presently underway in a greenhouse experiment using soil samples obtained from several locations of each soil type.

MARYLAND

Title: IMPROVEMENT OF RED CLOVER ADAPTED TO MARYLAND

Leader: R. C. Leffel

During the past 10 years, maternal line selection has been utilized in an effort to improve the species. Particular emphasis has been given to resistance to southern anthracnose, (Colletotrichum trifolii). A 7000 plant nursery was established in 1958 to evaluate progress to date in the breeding program. This nursery will serve as a source nursery for another cycle of selection if the material therein merits further consideration.

Title: VARIETY AND STRAIN TESTING OF FORAGE LEGUMES AND GRASSES

Leader: R. C. Leffel and A. Morris Decker, Jr.

Alfalfa: An alfalfa variety test at College Park was evaluated for its fifth year of production. DuPuits, Socheville, Narragansett, Atlantic, Vernal, Rhizoma, and Grimm were all significantly superior to Williamsburg in regard to forage yields during the fifth year. Average yearly production for the five year period, 1954-58, is given for each of the varieties in the test:

<u>Variety</u>	<u>Average yearly yields, tons/acre</u>	<u>Variety</u>	<u>Average yearly yields, tons/acre</u>
DuPuits	4.15	A 225	3.80
Socheville	4.07	Ranger	3.69
Narragansett	3.95	Buffalo	3.66
Atlantic	3.92	Sevelra	3.66
Vernal	3.87	A 224	3.57
Rhizoma	3.87	Talent	3.45
Grimm	3.86	Nomad	3.30
<u>Williamsburg</u>	<u>3.84</u>		

MEAN 3.78 tons/acre L.S.D. = 0.25 tons/acre C.V. = 9.0%
.05

This alfalfa variety test will be terminated as soon as prevalence of bacterial wilt in the material has been determined. New tests were established at College Park and at Trappe during 1958.

Red Clover: Differences among yields of red clover strains at four locations within the State were not as discernible as in some previous years. All strains exhibited exceptionally high yields. Chesapeake and several Maryland local strains constituted the highest yielding group. Chesapeake exhibited superior seedling stands at both College Park and Trappe.

Ladino Clover: All strains tested exhibited a lack of persistence during the second summer of the variety test. Pasture Laboratory Synthetic No. 1 and California Certified were slightly superior to remaining strains in regard to stands at the completion of the 1958 growing season. Yield differences among strains were very small, excepting the low yield of Pasture Laboratory Synthetic No. 2 (poor persistence).

Sudangrasses, Millets, Johnsongrasses, Sorgrasses, Sorghum alnum, and Forage Sorghums: Pearl millets were much more resistant to leaf diseases at two locations, College Park and Trappe, as compared to Sudangrasses. Gahi No. 1 was the most resistant of all pearl millets. Stoneville Selection, Stoneville Synthetic No. 1, and Georgia 337 were more resistant to leaf diseases than remaining Sudangrasses. The extreme variation found among Sudangrasses and pearl millets in yielding ability, aftermath production, date of anthesis, plant height and stalk diameter, resistance to leaf diseases, and leafiness indicate the need of evaluating the more desirable varieties of each species (Gahi No. 1, Starr, and Improved Starr Pearl millets, and Tift, Piper, Greenleaf, Georgia 337, Stoneville Selection, and Stoneville Synthetic No. 1 Sudangrasses) under different management practices.

Sorghum alnum, Johnsongrasses, and a Sorghum-johnsongrass hybrid were more resistant to leaf diseases than Tift or perennial sweet Sudangrass, but did not appear as promising as the better Sudangrasses and pearl millets. The lack of agronomic desirability and the extreme weed potential of these particular selections eliminate them from consideration as recommended forages.

Forage sorghums, corn, Gahi No. 1 pearl millet, and Tift Sudangrass were evaluated for yields under a silage management. Many of the forage sorghums were superior to corn in yield but most of them were much inferior to corn in regard to lodging resistance. Forage sorghums Atlas, RS 301 F, and RS 303 F were satisfactory in lodging resistance and comparable to corn in forage yields.

Bermudagrass: Variety tests at three locations in the Coastal Plain of Maryland over the past two years have demonstrated that Midland and Greenfield will survive winters in this area. Both Coastal and Suwannee varieties suffered severe winter injury at each location being eliminated entirely from some tests. Midland has been the highest yielding variety at all locations with Greenfield being next followed by Common, Coastal and then Suwannee.

Title: RESPONSE OF ORCHARDGRASS TO VARIOUS RATES AND RATIOS OF POTASSIUM AND NITROGEN FERTILIZATION

Leaders: C. B. Kresge and S. E. Younts

Yields were taken from orchardgrass plots established in the fall 1957. Various rates and ratios of nitrogen and potassium fertilizers were applied (1957 Annual Report, page 54). Maximum yield (3.78 tons/A.) was obtained when 400 pounds of N and 200 pounds of K_2O per acre were applied. Yields at the 200 pounds per acre rate of nitrogen were essentially the same, whether 50, 100, or 200 pounds of K_2O per acre were applied. The dry matter yields at these rates (3.52, 3.43, and 3.51 tons/A., respectively) were exceeded only by that at the 400 pounds of N and 200 pounds of K_2O per acre application. Plots receiving fall applications of nitrogen at 100 pounds per acre had higher yields than did split spring and summer or split fall and spring applications at the same rate of nitrogen; in all cases 100 pounds of K_2O per acre were topdressed.

Title: TIME AND RATE OF POTASSIUM APPLICATION TO ALFALFA AND ALFALFA-ORCHARDGRASS

Leaders: C. B. Kresge and S. E. Younts

A study was made of the effect of time and rate of potassium application on alfalfa and alfalfa-orchardgrass yields (1957 Annual Report, page 55). In the case of alfalfa alone, greatest dry matter yields were obtained at all rates of potassium when applied after the first cutting. Only two treatments resulted in alfalfa yields higher than the check (4.61 tons/A.): 200 pounds of K_2O per acre applied either at planting time (4.78 tons/A.) or after the first cutting (4.97 tons/A.). In general, alfalfa-orchardgrass yields exceeded those for alfalfa. Yields of the legume-grass association were, in general, highest when potassium was applied in early spring or just after the first cutting. It is interesting to note that, in contrast to the yield data for alfalfa-orchardgrass, the yields of alfalfa were lowest when potassium was applied in early spring.

Title: COMPARISON OF NITROGEN SOURCES ON ESTABLISHED BLUEGRASS SOD

Leaders: C. B. Kresge and S. E. Younts

Single and split applications of various rates of four nitrogen sources were made on established bluegrass sod in 1958 (1957 Annual Report, page 55). When single early spring applications of 80 and 160 pounds of N per acre were made, urea caused greater yield increases than did ureaform, $(\text{NH}_4)_2\text{SO}_4$, or NH_4NO_3 . However, when yields caused by split applications of nitrogen (one-half in early spring and one-half after first cutting) were compared, those where NH_4NO_3 was applied were the highest. In general, split applications caused greater yield increases than single nitrogen topdressings. The highest percent recoveries of nitrogen from ureaform, $(\text{NH}_4)_2\text{SO}_4$, and NH_4NO_3 were 32, 38 and 57 percent, respectively, at the 320 pounds of N per acre split application. The highest nitrogen recovery from urea was 56 percent at the single 80 pounds of N per acre application made in early spring.

Title: ALFALFA FERTILIZATION

Leader: John H. Axley

The application of 800 pounds of 0-10-30 to alfalfa resulted in 6 tons of hay this past year on plots at the University of Maryland Agronomy Research Farm. Applications of 800 pounds of 0-5-15 and 800 pounds of 0-5-10 resulted in 5.6 and 5.4 tons per acre of hay, respectively. Alfalfa treated with 0-10-30, 0-5-15 and 0-15-10 contained 1.7 percent, 1.25 percent, and 0.9 percent K at the end of the season. Literature indicates that when levels of K in alfalfa approach 1 percent, loss of stand may occur. So loss of stand in the 0-5-10 treatments should be imminent.

Title: THE EVALUATION OF PASTURES FOR LACTATING DAIRY COWS

Leaders: N. A. Clark, A. M. Decker, Jr., and R. E. Wagner - Agronomy Department; R. W. Hemken, R. F. Davis and J. I. Leslie - Dairy Department

In late summer of 1958 a grazing experiment was seeded at the University of Maryland Forage Research Farm. Grazing is to be started in the spring of 1959. The objectives of this study are: To compare orchardgrass under three rates of nitrogen, Midland Bermudagrass with sod-seeded cereal rye, and orchardgrass-Ladino clover as pasture for dairy cows based on the following criteria: (a) Dry matter production, carrying capacity, and forage quality of these pastures. (b) Animal response (intake level, persistency of milk production, and body weight changes) as affected by the pasture treatments.

Title: MANAGEMENT STUDY OF SUMMER ANNUALS

Leader: N. A. Clark

An experiment will be established in the spring 1959 to compare yield and persistency of ten varieties of Sudangrass and millet.

Under phase I of this experiment the plants upon reaching a height of 18 inches will be clipped to heights of 2 and 8 inches. Nitrogen will be applied at the rate of 50 pounds per acre to each harvest.

Two varieties of millet (Gahi No. 1 and Improved Starr) and one Sudangrass (Tift) will be studied in phase II. These plants will be clipped from heights of 18 and 30 inches to heights of 2, 4, and 8 inches. Plants under each clipping treatment will be further compared under 25, 50, and 100 pounds of nitrogen per acre applied to each cutting.

Title: GRASS AND LEGUME COMBINATIONS FOR BEEF PRODUCTION

Leader: A. Morris Decker, Jr. and R. Z. Spry

Evaluation of four pasture combinations for beef production in the Coastal Plain area of Maryland was continued for the third year (1957 Annual Report, page 55). Midland Bermudagrass overseeded with rye produced 709 pounds of beef per acre in 1957 and 750 pounds of beef per acre in 1958. This was 269 pounds better than orchardgrass-Ladino clover in 1957 and 327 pounds better than reed canarygrass in 1958, the next best pastures. Not only was the grazing season longer for the Midland-rye combination than for the other mixtures, but carrying capacities were higher during most of the time. In addition to this, daily animal gains were as good or better for Midland-rye than for the other pastures tested.

Title: EFFECTS OF IRRIGATION AND FERTILIZATION ON FIVE FORAGE SPECIES

Leader: A. Morris Decker, Jr.

The experiment was seeded in the fall 1957 (1957 Annual Report, page 56). Yields were determined for the 1958 growing season. Soil moisture was near optimum forage growth except during the last week of May, first week of June, first week of July and second week of September. Plots maintained at a low moisture tension received three irrigations totaling 5.38 inches of water. Plots allowed to reach high moisture stress before irrigation were watered once with 2.00 inches on June 6. Except for the first application on the low tension plots in May, sufficient rain fell after each

irrigation to essentially nullify treatment effects. Significant growth differentials occurred with all species except Midland as a result of the early May irrigation (Midland had not yet started to grow).

Weed-free dry matter yields for alfalfa were approximately twice those for Ladino clover (range of 2.57-4.52 tons per acre). Tall fescue was the most productive grass followed by bluegrass and then Midland. The latter was low mainly because establishment was not complete until late summer. No real difference occurred between the three fertility levels on alfalfa and Ladino clover. Significant yield increases from the three grasses were obtained with each increment of nitrogen. Forage yields ranged from 1.02 tons/acre for Midland at low nitrogen and moisture levels to 5.80 tons/acre for fescue at high moisture and high nitrogen.

Title: SOD-SEEDING ESTABLISHMENT TRIALS

Leaders: A. Morris Decker, Jr. and F. Graham Swain

Detailed work on sod-seeding cereal rye into Bermudagrass was carried out during 1958-59. Row spacings, seeding rates and nitrogen fertilization rates were studied. Also, pilot type species and fertilizer trials were carried out comparing several legume and grass species. Cereal rye appears to have the greatest promise with its high yield and ease of establishment.

Future plans include trials with the aim of finding the best methods for producing greater fall production from sod-seeded rye in Bermudagrass. Closer row spacing combined with higher seeding rates and higher nitrogen rates will be studied together with trials to ascertain the optimum sowing time.

Also, problems associated with sod-seeding into Kentucky bluegrass will be studied with particular emphasis on species, fertilizer placement and insect control at the time young seedlings are developing.

Title: INVESTIGATION OF FORAGE CROP INSECTS

**Leaders: A. L. Steinhauer, W. E. Bickley, L. P. Ditman, W. B. Phillips,
T. L. Bissell and R. Ratcliffe**

Research on forage crop insects is receiving major emphasis in entomology research in Maryland. Three sub-projects have been initiated under the above title in the past year. A full time forage crop entomologist has been hired, and 1959 will see the initiation of forage crop insect research on a permanent basis at the University of Maryland. Research presently underway will be primarily concerned with insect pests of alfalfa and clover, with a lesser emphasis on grasses and soybeans. There is as yet nothing to report in the way of experimental results.

Title: CONTROL OF VARIOUS WINTER ANNUAL WEEDS IN ALFALFA AND ALFALFA-GRASS MIXTURES - 1958-59

Leaders: P. W. Santelmann and J. A. Meade

Wild Turnip in Alfalfa - Fall seeded alfalfa was treated on 10/22/57 or on 4/18/58 with 2,4-DB at 0, 1-1/2 and 3 lbs./A. for the control of wild turnip (*Brassica rapa*). On 10/22, 15" rosettes of the weed were present. On 4/18, the weed had 8-inch flower shoots. The alfalfa was not injured by either treatment. Both rates of chemical resulted in 100 percent control of wild turnip when treated in October. When treated in April, the control was 32 percent for the 1-1/2 pound rate, and 65 percent for the 3 pound rate. Timothy in the mixture was also not injured.

Chickweed Control in Seeding an Alfalfa-Timothy Mixture - An alfalfa-timothy mixture was treated on 12/17 with CIPC, two forms of DNBP, and diuron to control chickweed. Hand separations were made to determine the effect of the herbicides on the yield of the grass. Best chickweed control was obtained with a 1 or a 2 pound rate of CIPC, the other herbicides being unsatisfactory. The only treatment that appeared to reduce the percent of grass in the harvest was the high rate (2 lbs./A.) of diuron.

The Control of German Knotgrass in Alfalfa - Fall seeded alfalfa was treated on different dates with split applications of DN and single treatments of CIPC in an effort to control this winter annual weed. There has been some evidence this spring of control with split applications of dinitro and single applications of CIPC. Whether this will be a feasible treatment is not yet certain.

Effect of CIPC on Various Grasses in Alfalfa - Although CIPC is not recommended for chickweed control in alfalfa-grass mixtures, there is some indication that some grasses might safely be sprayed. This experiment is designed to test the susceptibility of orchardgrass, timothy, brome grass, and tall fescue seeded in the fall with alfalfa. Treatments with the chemical were made in early March.

The Effect of the Time of Treatment upon the Susceptibility of Alfalfa to Dinitro and CIPC - At present the standard dinitro and CIPC treatments for chickweed control in alfalfa are very widely used. However, there frequently arises the question of treatment at sometime other than the optimum. The most highly recommended time for treatment is during December with the extremes being sometime in late November and early March. Frequently, however, farmers ask if it would be possible for them to treat later than the early March deadline. Occasionally, they want to know about treating sooner than our late November 1st treatment date; therefore, this experiment is set up to determine the effect on the yield of alfalfa of treating it before it is dormant in the fall or after it begins growth in the spring.

Treatments consist of the recommended rates of dinitro and CIPC applied at dates both before and after the optimum time.

MASSACHUSETTS

Title: EFFECT OF N AND K ON YIELD, COMPOSITION AND LONGEVITY OF ALFALFA-ORCHARDGRASS AND LADINO CLOVER-ORCHARDGRASS

Leaders: Mack Drake and W. G. Colby

The design of this experiment and the results for the first three years appear in the 1957 Annual Report, page 56-57. In 1958, the same three levels of K were employed as before but only two levels of N. However, the levels of N employed were much higher than applied previously. Again the response to K was low—the lowest level, 50 pounds K_2O , apparently being adequate. The response to N, however, was striking.

Alfalfa-Orchardgrass. The low level of N consisted of 50 lbs. of N early in the spring (April 22) and 25 pounds of N after the first and also the second cuttings. The high level of N was just double that of the low level, i.e. 100-50-50. Fifty pounds of N before the first cutting gave a good response - about 1250 pounds more cured hay per acre. Twenty-five pounds of N after the first cutting gave an additional 800 pounds and 25 pounds N after the second cutting, another 500 pounds. For the season, 100 pounds of N resulted in an increase of 2850 pounds of cured hay. The total yield for the no N series was 8100 pounds; for the N series 10,950 pounds. Doubling the rate of N gave no further yield increases. The proportion of legume to grass in this case was in the neighborhood of 60 percent legume and 40 percent grass. Not only yield results but also protein analysis indicated that the grass on the no N plots was not adequately supplied with N. Grass from the no N plots analyzed 12 percent protein while the low level N plots analyzed 16 percent protein. Doubling the rate of N increased the protein content only slightly.

One of the interesting sidelights of the alfalfa-orchardgrass plots is that after four harvest seasons, there is practically no Kentucky bluegrass in any of the plots; however, there is an excellent stand of alfalfa. Could it be that the persistence of a good stand of alfalfa is due in part to the exclusion of Kentucky bluegrass?

Ladino Clover-Orchardgrass. Practically all of the Ladino clover has disappeared from these plots except where no N has been applied and even here the stand is so poor it contributes very little to improving yields. In 1958 this was essentially a pure stand of orchardgrass. For this reason the rates of N application were substantially increased. Seventy-five pounds of N were applied early in the spring followed by 25 pounds N after the first three cuttings for the low level N rate, and double these quantities for the high level N rate. The response of orchardgrass to N was phenomenal. The no N plots produced scarcely a ton of dry matter all season. The 75-25-25-25 produced approximately 8600 pounds of cured hay, while doubling the N rate added an additional 1800 pounds of cured hay. Increasing the rate of N fertilization greatly increased the protein content of the grass as well. No N

grass had 11 percent protein, the low level N grass 13 percent, and the high level N grass 17.5 percent. More than half of this increase in yield was produced by the first crop which suggests that N applied early in the spring is more efficient pound for pound than applied later in the season. The relationship of rate of N and time of N application needs to be investigated further. Most of these plots have received no phosphorus since seeding when 800 of 20% superphosphate was drilled 2-3 inches deep in bands. Nevertheless the P content of all forage, both legumes and grasses - with one exception, was .3 percent or better. The one exception was .27 percent P.

Title: INSECTS IN RELATION TO FORAGE CROPS

Leaders: F. R. Shaw and R. J. Lavigne

The investigations comprising this project can be grouped in three categories: (1) Those involving survey of insect populations in forage crops. (2) Those concerned with the biology of certain injurious species. At present, we are emphasizing the clover root curculio complex, Sitona spp. (3) Those concerned with the control of forage crop insects.

The survey work considered three major problems including: (1) The distribution and abundance of forage crop insects throughout the entire state with particular emphasis on the occurrence of the alfalfa weevil Hypera postica Gyll. (2) The distribution and abundance of forage crop pests in relation to the composition of the stand. (3) The distribution and abundance of root injuring species, primarily Sitona spp.

During 1958 we collected approximately 66,000 specimens during our state survey. We have grouped these in descending order of abundance. Within each group the same arrangement is followed.

<u>Insects</u>	<u>Percentage of Total</u>
Aphids (primarily <u>Macrosiphum pisi</u>)	71.8
Plant bugs <u>Lygus lineolaris</u> <u>Adelphocoris lineolatus</u> <u>Plagiognathus politus</u> <u>Trigonotylus ruficornis</u> Others minor in occurrence	10.8

<u>Insects</u>	<u>Percentage of Total</u>
Leafhoppers	5.4
<u>Empoasca fabae</u>	
<u>Macrosteles fascifrons</u>	
<u>Aceratogallia sanguinolenta</u>	
<u>Endria inimica</u>	
Others minor in occurrence	
Beetles	3.8
<u>Sitona hispidula</u>	
<u>Hypera postica</u>	
<u>Popillia japonica</u>	
Others minor in occurrence	
Grasshoppers	3.4
<u>Melanoplus femur-rubrum</u>	
<u>Conocephalus fasciatus</u>	
<u>Melanoplus spp.</u>	
Miscellaneous insects	1.7
Sawfly larvae; Hemiptera, Homoptera and Coleoptera of minor importance	
Spittlebug	1.5
<u>Philaenus leucophthalmus</u>	
Lepidopterous larvae	1.3
Cutworms (<u>Euxoa messoria</u> and <u>Plathypena scabra</u>)	
Loopers	
Alfalfa caterpillar	

The distribution of the alfalfa weevil was of major concern to us. In 1957 it was found in Berkshire, Hampden and Bristol Counties. By July, 1958 it had been reported from each county on the mainland. No surveys were made on Martha's Vineyard or other islands.

In an attempt to relate insect populations to the composition of stands, surveys were made from May 2 to October 20 of five fields in Hampshire County, all near the University of Massachusetts; these consisted of two stands of alfalfa, two of mixed alfalfa, clover and grasses; and one of red clover and grass. In general specific insect populations followed quite closely the trends reported for the remainder of the state except that the alfalfa weevil was more abundant in the south central portion of the state.

These investigations indicate that there is a relationship between insect abundance and composition of stand. While recognizing the preliminary nature of this work, the following conclusions may be drawn:

(1) Populations of Sitona hispidula were more abundant in mixtures of alfalfa, clover and grass, and in red clover and grass than they were in pure stands of alfalfa. (2) Alfalfa, in which the last cutting was delayed until October, had substantially higher populations of aphids, spittlebugs and certain plant bugs than did those cut earlier. (3) Different species of leafhoppers appear to be selective in their choice of food plants, their abundance and distribution apparently being related to composition of stand.

The survey work concerning root injuring species was preliminary in nature. Immature specimens of clover root curculios Sitona spp. were most abundant. Larval Japanese beetles and undetermined species of wire worms were present in limited numbers. The actual records of these investigations will be included in the thesis of the junior author.

Effects of insecticides on forage crop insects: Applications of 2-1/2 percent granular Heptachlor were made for the control of immature Sitona spp., 1 pound actual per acre was applied in August, 1957 and to a second series of plots in April. The plots consisted of strips of alfalfa, Ladino clover, red clover, and birdsfoot trefoil. The populations in treated and untreated alfalfa and red clover plots were essentially the same. The populations in the Ladino clover and birdsfoot trefoil were significantly lower than they were in untreated plots. In Ladino clover there was a 95 percent reduction in plots treated in August with a 77 percent reduction in those treated in April. In birdsfoot trefoil reductions of 84 and 68 percent were obtained respectively for the August and April treatments.

Heptachlor 2-1/2 percent granular at rates of 1-1/2 and 3 pounds actual per acre, applied to alfalfa 10 inches high in May, resulted in no significant reduction in populations of immature Sitona spp.

Some preliminary experiments were conducted to determine the relative merits of two formulations of Sevin (50 percent WP and 45M), two American Cyanamid compounds (12,880 and 18,706) and Methoxychlor EC all at rates of 1 pound actual per acre. Of these, American Cyanamid compound 18,706 appears to be the most promising against aphids, plant bugs and some leafhoppers.

NEW HAMPSHIRE

Title: IMPROVEMENT OF SMOOTH BROMEGRASS, RED CLOVER AND ALFALFA

Leaders: G. M. Dunn and L. J. Higgins

Yield data were obtained in 1958 for 6 New Hampshire bromegrass synthetics (Syn. 1). Two or three of these produced good total and aftermath yields, and appeared to have good brownspot resistance in comparison to check varieties.

Cultural and inoculation studies were continued with Pyrenophora bromi. Conidial production was generally poor; some increase in conidia was obtained with a sporulating isolate grown on "V-8" agar. A total of 257 leaf lesion isolates was made; many did not produce conidia on PDA, and none was considered good in conidial production. These isolates differed remarkably in number and size of sclerotia and rate of mycelial growth. Approximately 20 of 45 leaf lesion isolates grown on grain (4-5 months at 6° C.) produced ascospores. Attempts to shorten this period were unsuccessful.

Twenty to thirty single ascospore isolates produced few if any sclerotia on agar or grain media.

S₁ progenies showed less brownspot than open-pollinated progenies in the field. In limited greenhouse tests, there was no difference between S₁ and OP progenies. Satisfactory field infection was obtained with infected leaves plus overhead irrigation. In the greenhouse, mycelial and conidial suspensions were not as effective as ground infected leaves or ascospores in producing infection.

DuPuits alfalfa performed comparatively well in yield trials at Dover and Colebrook.

Potted New Hampshire red clover plants have been continued in the greenhouse for crossing by bees in the spring.

The replicated red clover variety trials, seeded in 1956 were harvested in addition to the one harvest on June 13, 1957, on June 16, 1958 and August 13, 1958. Wisconsin 53P and Pennscott produced increased yields while New Hampshire and Dollard gave decreased yields in 1958 as compared to the 1957 yields.

Title: IMPROVEMENT OF WHITE CLOVER

Leaders: G. M. Dunn and R. A. Kilpatrick (in cooperation with Forage and Research Branch, ARS, USDA)

Plots were established at 2 locations with the following treatments: (a) Methyl bromide; (b) dieldrin; (c) methyl bromide plus dieldrin; and (d) check. Periodic samples will be made to determine the effects of these materials on clover curculios and the root rotting fungi, and the relationship of these organisms to taproot deterioration. Yield and persistence data will also be obtained on these plots.

Yield data will be obtained in 1959 on several Ladino clover synthetics. At present, approximately 75 Ladino clover selections are being progeny tested in 5 x 5 foot observational plots.

Yield data were obtained on the Colebrook test (1957 Annual Report, page 61). Pilgrim was again highest for the clover fraction.

Surveys of diseases attacking clovers were continued in 1958. The yeast spotting disease was found only in New Hampshire. The phyllody complex (aster yellows virus) was found throughout northern and eastern Maine. Neither of these diseases has been found in other New England states.

The causal organism of the yeast spotting disease was identified as Rhodo-torula glutinis (Fres.) Harrison var. rubescens (Saito) Lodder. The fungus overwinters on diseased leaves. Optimum growth, in culture, occurs near 24° C. The fungus causes a disease, which results in cellular breakdown and disorganization of host leaf tissue. Inoculation tests in the greenhouse suggest that the fungus is of importance only in areas of prolonged high humidity.

Observations were continued on survival of Ladino clover taproots at 2 locations. Relatively few living taproots were found in June, and none in August, 22-24 months after seeding. Root rot was more pronounced at Northwood than at the Strafford County Farm. In addition, the highest larval populations of Sitona spp. were found at Northwood.

Isolations were made from diseased roots from both locations. Numerous fungi were isolated although Fusarium oxysporum comprised the highest percentage of isolates.

Isolations were made from larvae of the Sitona spp. Beauveria bassiana comprised the highest percentage of isolates. Other fungi isolated consisted of Penicillium spp., Fusarium oxysporum, Metarrhizium anisopliae, Mucor spp., Trichoderma sp., Rhizopus nigricans, Cladosporium sp., F. roseum, F. solani, Alternaria sp., Chaetomium sp., and several unidentified species.

Screening studies were continued with Curvularia trifolii. Resistant plants were transferred to the field for further observations.

Studies were initiated on the role of clover diseases in relation to winter survival. Two diseases, Curvularia leaf spot and Stemphylium leaf spot, are being used for present studies on both red and white clover. Methods of testing hardiness of clovers are being standardized.

Controlled studies were initiated in September to determine the role of the clover root curculios, Sitona hispidula and S. flavescens, in relation to root rot and persistency of the taproots. Eggs of the respective species were placed in pots of soil with and without Fusarium oxysporum. Pots with and without the fungus were also examined in January, 1959. Extensive injury was noted on roots where eggs were applied. Injury was somewhat heavier in pots of S. hispidula although this was apparently due to a longer larval feeding period. The insects do not appear necessary for invasion of root rotting fungi although they increased the available areas of invasion, which leads to early death of the taproots.

Preliminary studies were conducted on the stomata of Ladino clover leaves. Stomata were smaller and most numerous on the upper epidermis. The number of stomata for the upper and lower leaf surface was 7,698 and 5,529/sq. cm., respectively.

Title: COMPARATIVE LIFE HISTORY AND DISPERSAL OF SITONA FLAVESCENS AND S. HISPIDULA

Leader: William R. Lee

Preliminary investigation on forage insects indicated a large number of larvae of Sitona spp. feeding on white clover roots. The larval population reached its highest peak in early June and a smaller peak in early September. The larvae that comprise these two population peaks cannot at present be separated morphologically; however, adults of the clover root curculio, Sitona hispidula (F), and S. flavescens Marsh. were the only two species of Sitona found in abundance in fields of white clover.

Egg laying was determined by placing field collected adults of both species in oviposition chambers. These oviposition chambers were made by placing 20-mesh screen wire over the opening of a pint fruit jar and inverting the jar over a petri dish containing water. Petioles of white clover were placed in the jar with their cut ends extending through the screen into the water.

In June adults of S. hispidula were very rare; however, by mid-July teneral specimens of this species became prevalent. Adult S. hispidula collected during July, August, and September did not lay eggs except for three eggs from a group of 25 adults on September 25. However, adults collected during

October and November laid eggs when placed in the oviposition chambers. In contrast, ovipositing adults and teneral specimens of S. flavescens were collected throughout the summer. From these field observations it is believed that S. hispidula larval development occurs during May and June, while S. flavescens larvae occur whenever conditions permit. Therefore, apparently the June peak in larval population is due predominantly to larvae of S. hispidula while the larvae in late summer are predominantly S. flavescens.

A high mortality was observed in holding adults and rearing larvae under both field and greenhouse conditions. Two species of fungi were isolated from dead larvae and adults of both insect species. Dr. R. A. Kilpatrick identified the fungi as Beauvaria bassiana and Metarrhizium anisopliae both of which are known to be insect pathogens. From field observations it is believed that pathogenic fungi are largely responsible for the biological control of these two insects.

Title: SOIL FERTILITY STUDIES OF FORAGE CROPS

Leaders: A. B. Prince and P. T. Blood

The effects of lime, phosphate, and potash applications on the yields of alfalfa-bromegrass, Ladino clover-bromegrass, alfalfa-orchardgrass, and Ladino clover-orchardgrass mixtures are being studied at 3 locations. Three years' data from the Colebrook, N.H. location (Worthington loam) showed that the Ladino-bromegrass mixture consistently outyielded the alfalfa-bromegrass mixture at soil of pH 5.5. At pH 6.5 the yield of the Ladino-bromegrass mixture was more than double that of the alfalfa-bromegrass mixture during the first harvest year. Thereafter the yields of the alfalfa-bromegrass mixture were superior. Percent crude protein varied from 2 percent to 8 percent higher in the second cut of both mixtures than in the first cut. Liming from pH 5.5 to 6.5 significantly increased the crude protein percentage in the alfalfa-bromegrass forage. Hand separation of forage samples showed a marked effect of liming on the percent alfalfa in the stand, but only a relatively slight effect on the Ladino clover. After the first harvest year the amount of Ladino clover in the forage was reduced by more than 50 percent, while the amount of alfalfa gradually increased.

Title: WATER AND FERTILIZER REQUIREMENTS OF SELECTED CROPS AND SOILS AS
RELATED TO IRRIGATION

Leaders: A. B. Prince and P. T. Blood

A lysimeter experiment was set up in a growth chamber to study the effects of water treatment, fertilizer level, and soil temperature on (a) yields of tops and roots of Vernal alfalfa, (b) amount of water moving through the soil, and (c) amount of cations leached. The data obtained indicated the following:

(a) yields of alfalfa were much lower when grown in a soil temperature range of $15 - 18^{\circ}$ C. as compared with 20° or 30° C. (b) There was a yield response to fertilizer. (c) At the $15-18^{\circ}$ C. and the 30° C. soil temperatures, irrigation with 2 acre-inches per week (R_1) or acre-inch twice per week (R_2) resulted in higher alfalfa yields than irrigation with 2 acre-inches once every two weeks (R_3). At the 20° C. soil temperature no consistent pattern of yield developed. (d) In general the alfalfa yields were highest under intensive irrigation, R_1 and R_2 and fertilized soil, F_1 and F_2 . (e) The effects of irrigation, fertilizer, and soil temperature treatments on total root growth were similar to the effects on top growth. (f) The amount of leachate collected from the soil was markedly affected by soil temperature, being highest at $15-18^{\circ}$ C. and lowest at 30° C. Irrigation treatments R_1 and R_2 resulted in larger amounts of leachate than R_3 . (g) The amount of Ca. in the leachate was roughly proportional to the amount of leachate obtained under the several irrigation and soil temperature treatments. (h) the amount of Ca. in the leachate was also proportional to the fertility level employed, being highest at the highest fertility level and lowest for the unfertilized soil.

Title: THE EFFECT OF SOIL TYPE AND MINERAL ADDITIONS ON THE MINERAL CONTENT
OF TIMOTHY AND CLOVER

Leaders: G. P. Percival and D. Josselyn (with the cooperation of K. C. Beeson of the U. S. Plant, Soil and Nutrition Laboratory, Ithaca, New York)

Two experimental plots were sampled to measure the increase in uptake of cobalt due to a topdressing of 5 lbs. of cobalt per acre at the start of the experiment. Previous work had shown that at the end of 5 years the 2-lb. topdressing of cobalt per acre no longer increased the cobalt uptake.

Timothy samples taken 10 years after topdressing a Paxton loam with 5 lbs. of cobalt per acre showed that the treatment was no longer effective in increasing the cobalt content. The average for all the plots was low at 0.02 ppm. This field had been plowed twice during the 10 years.

Timothy and quackgrass were sampled 7 years after a Gloucester fine sandy loam had been topdressed with 5 lbs. of cobalt per acre. The results showed that the cobalt content of the timothy was higher than that of the quackgrass. The respective averages were 0.15 ppm. and 0.06 ppm. Liming had a depressing effect on the uptake of the cobalt. The average of the unlimed treatments for timothy was 0.18 ppm., while the limed average was 0.12 ppm. The corresponding figures for the quackgrass were 0.08 ppm. and 0.04 ppm. respectively. This field had not been plowed during the experiment.

Title: ECONOMIC EVALUATION OF FORAGE PRODUCTION AND UTILIZATION IN NEW HAMPSHIRE

Leader: G. E. Frick

Seasonal and annual forage growth rates with respect to management level have been established for several of the important soils. Feed quality restrictions are being developed.

These data will be incorporated within typical farming patterns to approximate optimum forage production and utilization designs. Major variables to be considered are: herd size, milk output in relation to quantity and quality of feed, livestock-acreage restrictions, cropping programs, price relationships, capital limitations and other qualifications.

Title: MINERAL DEFICIENCIES IN FORAGES GROWN UNDER HEAVY FERTILIZATION

Leaders: H. A. Keener and B. Clark (in cooperation with E. J. Thacker and K. C. Beeson of the U. S. Plant, Soil and Nutrition Laboratory, Ithaca, New York)

Previous work carried out at this station has shown that timothy grown on heavily fertilized soil may be deficient in cobalt, iodine and unknown nutritional factors. Recent work at the U. S. Plant, Soil and Nutrition Laboratory with New Hampshire grown timothy has indicated that the unknown nutritional abnormality can be corrected by altering the cation-anion balance of the ration. This work is now being repeated with calves.

Title: PLANT ESTROGENS AND THEIR EFFECTS ON REPRODUCTION IN CATTLE

Leaders: P. A. Wright, H. A. Keener and F. E. Allen

Twenty-four Holstein heifers were fed varying doses of diethylstilbestrol at the rate of 0, 0.2, 0.4, and 0.8 mg. per day with conception rates at first service being 67 percent, 50 percent, 17 percent, and 67 percent respectively. Since the 0.2 and 0.4 mg. dosages are comparable to levels of activity reported in forages with high levels of estrogen, these results suggest that estrogen levels in certain forage crops may have an adverse effect upon conception rate, but that higher levels may bring about a compensating effect in the endocrine system of the animal. This experiment using 48 heifers is now being repeated.

Work is now in progress attempting to show similar effects in small mammals. Fertility in rabbits is being tested after maintaining animals for 6 weeks on varying dosages of diethylstilbestrol comparable by weight to those dosages used in the heifer studies. Histological studies on pituitary glands are planned to ascertain whether certain forage diets may affect pituitary cytology and thus reproductive physiology. Ladino clover was shown to have decided estrogen activity (>10 LU/gm.) when bioassayed on immature rats, an observation confirming the work of other investigators.

NEW JERSEY

Title: PRESERVATION OF SURPLUS SPRING PASTURAGE IN PLASTIC MATERIALS AS SILAGE

Leader: M. A. Sprague

Versatile reusable forms for stacking silage in the field are to be desired as a means of rapidly building small stacks in out-of-the-way places. Galvanized iron forms consisting of specially designed panels measuring 20" x 4' were designed and built for use in building 10' diameter stacks. Five stacks were built during 1958 representing crops of alfalfa, sorghum, grass-legume hay, and corn. Each of the stacks was built easily and retained its shape effectively throughout the storage period.

Previous experiments utilized 8 mil. thickness vinyl film as successful covers. Trials with 6 mil. film were successful. Four mil. film was observed to be too lightweight to persist for long-term storage. Small breaks in the film grew to complete failure in about two months during the fall season. In repeated trials 8 mil. vinyl covers have been used five and six times.

Title: PASTURE RENOVATION STUDIES

Leaders: M. A. Sprague, R. D. Illnicki and R. W. Chase

During 1958 dalapon + amitrol, cacodylic acid and dalapon followed in 3 weeks by cacodylic acid on the day of seeding were tested for their effectiveness to completely kill a bluegrass sod during the last two weeks in May. Previous applications of nitrogen fertilizer at 0, 66, and 148 pounds followed by heavy grazing during April and May had no effect on the degree of kill. Best kill was obtained by dalapon 4 pounds + amitrol 1 pound on May 14 and by dalapon 4 pounds followed by cacodylic acid 2 pounds in split applications.

First harvest yields of Sudangrass planted June 6 ranged from 54 to 2200 pounds dry matter per acre depending upon the degree of kill of the old sod. This emphasizes again the principle of competition between live, well established perennials and new seedlings.

Cacodylic acid at 12 pounds per acre applied on the same day as seeding had no obvious effect on seedling growth.

Title: FERTILIZER STUDIES WITH ALFALFA

Leaders: G. H. Ahlgren and J. L. Gerwig

Applications of fertilizer to the alfalfa study initiated in 1952 (1957 Annual Report, page 66) continued for the sixth consecutive year and harvests were made during 1958. Potash continued to be the key item with respect to yield and persistence of stand. For the first time, 1958 responses of 300 pounds of potash per acre over the 200-pound level were observed. At 300 and 400 pounds per acre, yields of alfalfa hay per acre were above 5.0 tons in 3 cuttings.

The time of fertilizer application study showed, as it had in other years, that at least part of the fertilizer must be applied in the spring. Even though these plots have received 200 pounds of K_2O annually, there has not been a reserve built up in the soil in sufficient amounts to carry the crop through the first cutting.

The highest yields were obtained when 1/2 of the fertilizer was applied in the spring and 1/2 following the first cutting. The second and third cutting yields were not altered significantly by different time of fertilizer application.

Molybdenum has become a limiting factor in the sixth harvest season. This is the first year that any significant increase in yield has been obtained. Boron showed no significant differences this year.

Table 1. The yield of alfalfa as influenced by different rates of K_2O with no nitrogen applied and P_2O_5 held constant.

Fertilizer applied yearly in March	Dry matter - Tons per acre of alfalfa 1958
0-0-0	0.06
0-100-0	0.07
0-100-50	2.87
0-100-100	4.12
0-100-200	4.51
0-100-300	5.17
0-100-400	5.00

Table 2. The yield of alfalfa as influenced by different time of fertilization.

Time of fertilization	Dry matter - Tons per acre of alfalfa 1958
None	0.06
Spring	4.83
First	4.31
Last	4.80
Spring - First	5.06
Spring - Last	4.88
First - Last	4.47
Spring - First - Last	4.86

Title: GENETICS AND BREEDING OF FORAGE LEGUMES

Leaders: W. R. Battle, F. Olsen and L. Almodovar

I_2 progenies and $I_1 \times I_1$ combinations were produced in a study of inheritance of anthocyanin pigmentation in alfalfa. This is an apparent case of quantitative inheritance in which the various classes range from pure white through several intermediate types to purple. Distribution of the I_1 progeny was studied in a field planting and was found to approximate a normal curve, with the parental type falling midway in the curve. Selected plants were removed to the greenhouse and selfed seed as well as seed of crosses to the pure white segregates was produced. In the study of inheritance of feeding value, a field

planting was established to compare protein production in high- and low-protein parents, their single-cross combinations, and the I_1 progenies derived from them.

Title: HORSE PASTURE RESEARCH

Leaders: R. W. Duell and R. J. Marrese

Comparisons of the three most plausible methods of phytin analysis are in progress in an attempt to evaluate their accuracy and precision. Plant species, varieties and plant parts are being analyzed with these three methods, at various stages of plant maturity and grown under different fertility levels, to determine the distribution of phytin in plants.

The production of 2.5 T/A of Midland Bermudagrass during the drought season of 1957 was considered pleasing; however, during 1958, a season of favorable moisture condition, yields exceeded expectations. At New Brunswick, 5 tons of dry matter per acre were obtained from three cuttings while yields increased at southern locations to 6 tons in Burlington County and 8 tons in Cape May. Yields were increased in all instances with each increment of fertilizer. The yields reported above were obtained from the highest rate of 10-10-10 applied, viz., 800 lbs./A. before each cutting.

For the third harvest year all six species of common perennial forage grasses responded to differential fertilization with 10-10-10; however, yields of timothy and brome grass have been declining under this pasture-type cutting management. The positive responses of the first two cuttings were quite marked but only slight differences appeared in the third and a negative trend existed in the fourth cutting. This deterioration in yield is attributed to potassium depletion of the soil. Chemical analyses indicate that more potassium was removed in harvesting than was applied each year. Potassium deficiency symptoms were quite evident on the orchardgrass plots prior to the last cutting.

Small plot field studies with fertilizer-seed placement of alfalfa and birdsfoot trefoil suggested inherent differences in the seedling responses of these species. Birdsfoot trefoil emergence and development was adversely affected by proximity to concentrations of soluble fertilizers. To a degree, alfalfa was benefited by such conditions.

For the fourth consecutive year, Wheeler Sudangrass was the highest yielding entry in Sudangrass and millet variety trials cut three times per season to simulate grazing. It appears that earlier maturing types are superior to later maturing when harvested frequently, as in pasturing.

Increased yields of Sudangrass were obtained from the first harvest with each increment of seed sown. Subsequent harvests were negatively related to seeding rate unless nitrogen was applied after the first harvest at 50 lbs./A. or more.

Title: NITROGEN ON ALFALFA

Leader: E. R. Purvis

Application of 200 pounds N per acre resulted in significant increases in yield and protein content of Atlantic alfalfa over a 5-year period when crop was harvested 4 times annually in pre-bloom stage. No response to applied N was obtained when crop was harvested 3 times annually in the early bloom stage. Applications of K at rate of 300 pounds K_2O per acre gave significant increases in yield over 200 pounds per acre applications in 3 out of 4 comparisons. N treatment believed to be economic only where forage containing more than 20 percent protein is desired. Paper reporting results obtained has been submitted for publication.

Title: HIGH NITROGEN GRASS PRODUCED BY HEAVY NITROGEN FERTILIZATION

Leaders: C. H. Ramage and C. Eby

After six years, the grass plots established in the fall of 1952 are highly productive and completely free of weeds. Some loss of stand has occurred on the orchardgrass under very high levels of nitrogen fertilizer. With adequate amounts of phosphorus and potash supplied, orchardgrass and reed canarygrass plot yields in 1958 were as follows:

	ORCHARDGRASS							
	0# N	50# N	100# N	150# N	200# N	300# N	400# N	600# N
D.M., lbs./acre	4000	5200	6020	6520	6960	7580	7620	7940
Protein, %	11.2	13.4	13.3	14.1	17.1	18.2	19.8	19.6
Protein, lbs./acre	450	700	800	920	1190	1380	1500	1560
% N recovery	----	79.4	56.2	50.0	59.2	49.5	42.2	29.5

	REED CANARYGRASS							
D.M., lbs./acre	2780	4750	5520	5900	7200	8300	9100	9040
Protein, %	12.6	14.9	15.0	15.8	17.2	19.6	21.6	21.9
Protein, lbs./acre	350	710	830	930	1230	1630	1960	1980
% N recovery	----	115.0	76.3	61.8	70.8	68.1	64.5	43.6

NEW YORK (CORNELL UNIVERSITY)

Title: BIRDSFOOT TREFOIL BREEDING AND GENETICS

Leaders: P. R. Henson, R. R. Seaney, and D. Gershon (ARS, USDA in cooperation with Cornell University, Ithaca, New York)

Accessions of L. corniculatus, L. tenuis, and L. uliginosus have been collected and placed in space-planted nurseries. Open-pollinated seed of selected plants of L. corniculatus has been collected for testing of progeny in small plots. These clones were selected on the basis of vegetative vigor, recovery growth, erect growth habit, and high seed yield.

During the summer of 1957, superior S_1 progenies were selected for further inbreeding. Only about 55 percent of the S_1 plants set seed. It has been noted that self-fertility values of individual clones of Viking are not similar from year to year, and in addition, that the order or ranking of these clonal self-fertility values changes from year to year.

Simple selection has not been successful in obtaining plants of L. corniculatus resistant to seed shattering. Interspecific hybridization is being used in an attempt to transfer the shattering resistance of L. uliginosus into L. corniculatus. The cross, tetraploid L. uliginosus ($2n = 24$) x L. corniculatus ($2n = 24$), has been selfed and backcrossed to L. corniculatus. The chromosome number of L. coimbrensis ($2n = 12$) has been doubled and the tetraploid will be crossed with L. corniculatus.

Cyanogenesis in L. corniculatus is determined by a single dominant gene inherited at the tetrasomic level. Results to date, indicate that

cyanogenesis in L. tenuis is controlled by at least two genes. Mottled seed appears to be dominant over non-mottled seed in both L. corniculatus and L. tenuis. Seed coat mottling in L. hispidus ($2n = 24$) is controlled by a single dominant gene.

Studies are being completed to determine the amount of cross- and self-fertilization occurring when cross-pollinating L. corniculatus without emasculation. Cyanogenesis is being used as the dominant marker in this study.

Title: BREEDING AND CYTOGENETIC INVESTIGATIONS WITH THE FORAGE PLANTS OF NEW YORK

Leaders: R. P. Murphy, R. E. Anderson, C. C. Lowe

Studies are in progress with alfalfa, birdsfoot trefoil, smooth brome grass, timothy and orchardgrass. (1957 Annual Report, page 71).

Clonal evaluation is in progress on all surviving selections made in previous breeding programs in alfalfa at this station. These breeding programs were for bacterial wilt resistance, leaf spot and leaf hopper tolerance, carotene content and combining ability. Additional selection will be made in single cross progenies from the best regionally adapted and progeny tested clones.

Incorporation of bacterial wilt resistance into Narragansett and DuPuits is being continued by inoculation of backcross seedlings and field planting and selection in infested fields. Third backcross generations, respectively, of Narragansett and Flemish material have been produced this winter. Second generation backcross selections (87.5 percent recurrent parent) of both varieties were intercrossed and the intercrossed seed will be increased in California in 1959 for use in establishing plot tests in New York in 1960.

Evaluation is in progress for clonal, selfed and various intercrossed progenies of Narragansett clones selected for high and low seed production in a Foundation field at Riverton, Wyoming in 1957. Similar selections were made in a production field at Firebaugh, California in 1958 and the various progenies will be similarly studied. Greenhouse evaluation of seed set for the selected clones has been generally well correlated with field index for seed production as noted at the time of original selection.

Scoring of the creeping-rooted alfalfa nursery composed of third generation intercrosses showed 30 percent of the plants exhibiting the creeping character after only one year in the field. Eighty-nine percent of all plants in the current cycle of selection eventually show the character. Some families are essentially true-breeding for this character. Experience to date is that the character can be fixed quite rapidly in segregating generations and that selection is very effective for increasing frequency of creepers and early

creepers. Selection is being continued for upright growth habit and seedling vigor within the current material in which gene frequency for creeping is high.

Studies of irradiation effects expressed in advanced generations after treatment is continuing for brome grass, timothy and orchardgrass. R₃ progenies (from seed receiving fast neutron exposure) are under observation. Additional studies are being made on effects of high level X-ray treatment of alfalfa and birdsfoot trefoil seed on seedling growth. Noticeable stimulation produced by certain levels on freshly treated seed was not observed when seed aged after treatment was used.

Plantings and facilities are being made to effect all possible single-crosses within several groups of second-cycle clones of orchardgrass and timothy to trace inheritance patterns of desirable clonal characters in these species. Preliminary results on progeny performance of two-clone combinations of alfalfa indicate that a high degree of uniformity and heritability to the progeny for color and growth characteristics was evident from two New York clones which were crossed to a series of selected clones from other areas. The clonal characteristics were distinct in the progeny over a wide array of crosses.

Title: STRAIN TESTING AND BREEDING OF FORAGE PLANTS FOR NEW YORK STATE AND VICINITY, WITH SPECIAL EMPHASIS ON PROBLEMS OF PRODUCTION DURING PERIODS OF MID-SUMMER DROUGHT

Leaders: C. C. Lowe, R. E. Anderson, R. P. Murphy, A. A. Johnson, and H. A. MacDonald (Agronomy) cooperating

(1957 Annual Report, page 74)

Evaluation of forage varieties and mixtures is conducted by trials in all of the important agricultural areas of the state. Sites are chosen in consideration of the cultural limitations of soil drainage, depth, and fertility. It has become evident that varieties and mixtures interact strongly with management. Determination of optimum management for maximum expression of the genetic capabilities of varieties and mixtures is an essential requisite of forage evaluation.

Alfalfa: The improvement made through the introduction and use of new alfalfa varieties during the 1950's is one of the most significant changes ever to occur in New York agriculture. Potential forage production per acre and quality of forage have both been greatly increased by the expansion of the areas where alfalfa can be successfully grown. Nearly all alfalfa seed sold is now of improved and recommended varieties; acceptance of improved varieties in New York is more complete than for any other area of the country or any other major field crop.

In addition to nearly doubled acreage and higher yields, the figures on seed sales reflect that success in establishing seedings has also been greatly improved through use of improved varieties and associated improved agronomic practices. Regional and station tests conducted under this project have had great significance in determining the proper use and management of the varieties now in use and their acceptance by farmers and seed handlers.

Greatest opportunity for continued expansion in the use of alfalfa is on land which has moderate and variable drainage. Before current varieties were available, successful establishment was too uncertain for alfalfa to be relied on as a major mixture component for this type of land. Red clover, therefore, was New York's principal legume despite its disadvantages of being short-lived and detrimental through competition to survival of other legumes in forage mixtures. Extensive trials throughout the state have now demonstrated that Narragansett alfalfa with judicious management will establish and survive sufficiently well so that it can be used alone or in combination with Viking trefoil to replace red clover and add several years of stand life of the mixture legume on moderately-drained land. These types of soil predominate on the extensive dairy areas of the Southern Tier and North Country regions of New York.

On the productive limestone soils of the state, or well-drained acid soils which have been neutralized by lime application, alfalfa has been grown successfully for many years. Long stand life was traditionally referred to as the hallmark of success for alfalfa on this type of land — and long-lived strains originally were a much sought for objective. Many trial results have indicated, however, that while alfalfa with proper care on this type of land may survive for many years, the peak period of productiveness is in the first three years of stand life. It has become obvious that shorter length of stands has the potential to raise the annual forage production level with alfalfa. This was not desirable before the present vigorous improved varieties were available because of the uncertainties of establishing stands. It was formerly a poor gamble to plow up fair three-year stands on the possibility that new seedings would be successful. The greatly improved seedling vigor of the currently recommended varieties and the improvements in machinery for cultural operations have removed this barrier. As a result, there is great interest in intensive management of alfalfa which produces maximum yields and quality by more frequent cutting in short-term stands.

The Flemish varieties, of which DuPuits is the best known, are ideal for this purpose. This variety was introduced into the Northeast and recommended on the basis of information gained in many trials conducted under this project. A number of other varieties of the same growth type have been evaluated. DuPuits was recommended because of consistent high production and because it has a reliable program of maintenance of basic stocks and seed increase. Alfa, a Swedish variety which is performing similarly to DuPuits, was bred for greater winterhardiness and could possess advantages under some conditions. As judged by tests to date, Alfa also has a sound seed stock maintenance and increase program.

The principal variety still in use is Ranger. Although still recommended and superior to common alfalfa of unknown origin, it is inferior to other recommended varieties for specified areas of use. Vernal is superior in all places where Ranger has been recommended. This variety has resistance to bacterial wilt and should be used where long stand life is desired. It is equal to Narragansett on well drained soils but not as productive on those of marginal drainage.

Several new synthetics of Northeastern breeding are being extensively tested and appear promising for certain categories of use.

Red Clover: Although use is declining, this legume is still of major economic importance. The varieties Dollard and Pennscott have proved better than common seed lots. Because of a high capacity for local adaptation in this species, native strains frequently give a good performance. However, there is no reliable way for the seed purchaser to discriminate among or determine the origins of common seed. The improved varieties are usually equal to best native strains and superior to others.

Dollard is moderately resistant to Northern anthracnose, a foliar disease which has caused frequent damage to susceptible varieties in recent years.

Hay and Pasture Grasses: A series of trials involving experimental synthetics of brome grass, orchard grass, tall oat grass, reed canary grass and timothy in different associations has been completed. Five years of data have been accumulated. Productiveness of these species under four-cutting-management was in direct order with their maturity classification.

In pure grass culture with nitrogen, tall oat grass which is earliest, was extremely productive with heading occurring two or three times in a single season. Reed canary grass gave the next greatest production followed closely by orchard grass. Smooth brome grass as a species was a poor fourth under this management. With alfalfa in mixture under the same management, tall oat grass mixtures gave highest yield followed by brome grass and then orchard grass. The fraction of five-year yield supplied by orchard grass was about 55 percent whereas brome grass contributed about 15 percent to its total mixture yields, partly due to loss of stands. Some experimental synthetics were clearly superior in yield to the best commercial varieties of brome grass and orchard grass; this was not true in reed canary grass or tall oat grass. Performance of the best synthetics in any species did not materially alter the general yield and competition relationships discussed above for species.

Smooth Brome grass: Brome grass has been found to be very desirable for use with alfalfa. Its spreading tendencies are excellent for maintaining mixture yields because it fills in where initial legume stands become sparse as the stand increases in age.

Saratoga is the best of a number of experimental synthetics tested and is undergoing seed increase. It is about 30 percent better in aftermath production than Lincoln or other Southern-type varieties of commerce. It has been found to pair well with vigorous alfalfas like DuPuits or Narragansett but its extra seedling vigor may adversely effect the stand of less competitive companion-mixture legume varieties or species. Most trial comparisons indicate timothy is preferable to brome grass in birdsfoot trefoil mixtures.

Orchardgrass: Extensive trials are in progress to compare the productiveness of later-maturing orchardgrasses with brome grass which has comparable maturity and fulfills the same use pattern as a late orchardgrass.

Trials have conclusively shown the relationship of maturity to season production in this species. Varieties later than one week in maturity than Common will have less season yield potential. Studies of dry matter content at harvest, a factor known to be associated with digestibility of forage, has shown consistent differences between varieties of different maturity as based on anthesis date. Studies are underway to compare these by animal evaluation. In general, late strains do not head as well and a higher proportion of the spring vegetative growth is leaves rather than seed heads.

To date, there has been little difference in competition with other species in mixture for orchardgrasses of different maturity. There is some evidence that part of the aftermath deficiency between late and early strains may be made up by more efficient use of additional nitrogen if favorable moisture conditions prevail.

Timothy: As in orchardgrass, the objective of breeding and evaluation in this species has been toward improving forage quality in late season harvest of hay by using varieties of later anthesis date. Even a small improvement would be of wide agricultural significance because of the amount which timothy contributes to the state's total forage production.

The relationship of maturity to yield is the same as in orchardgrass. Strains one week later than Common can yield as much total season production; later ones are less productive but have greater quality potential. Climax, an intermediate type, is recommended wherever Common is now grown. Essex, a very late type, is two weeks later than Common in anthesis and should be used where late hay harvest of timothy is anticipated.

Title: BREEDING AND EVALUATION OF FORAGE CROPS ADAPTED TO THE NORTHEAST.
SUB-PROJECT I: BREEDING AND EVALUATION OF IMPROVED VARIETIES OF
FORAGE CROPS ADAPTED TO NEW YORK AND ADJACENT AREAS OF THE NORTHEAST

Leaders: C. C. Lowe, R. P. Murphy, R. E. Anderson and A. A. Johnson

(Refer to 1957 Annual Report, page 73).

The testing of seed stock lots of DuPuits alfalfa imported from France and their domestic seed increases have been continued for any evidence of genetic shift. The current increase program has proved satisfactory.

Ninety-six clones of brome grass from the second cycle of selection are being progeny tested currently under two intensities of cutting management (three cuts and four cuts per year). First year results suggest differential progeny performance under the two managements. If subsequent results confirm current findings, present breeding procedure with this species may need alteration. Cutting management in progeny evaluation would need to conform exactly with specified breeding objectives; opportunity may exist for breeding brome varieties to be used under specific management procedures.

A series of three inclusive trials of orchardgrass varieties and synthetics of different maturity is being conducted in cooperation with two other Northeastern states. Early results from New York trials strongly confirm previously reported results from this location on differential competition effect by species and varieties of grass on the establishment and maintenance of the companion legume in mixtures. In order of competition with the legume were: (1) orchardgrass, (2) Saratoga brome grass, (3) Lincoln brome grass, (4) Climax timothy, (5) no grass. As previously noted, early vs. late strains of orchardgrass appear equally competitive although highest production over the season is in favor of mixtures involving orchardgrasses of earliest maturity. The effect of grass competition within the mixture on total mixture yield is dependent on the ability of the grass variety or species to give compensating production for any loss of legume stand caused through competition. The competitive ability of the legume determines the break point in mixture yield as influenced by the grass competition. DuPuits alfalfa has proved capable of tolerating much greater grass competition than Narragansett or Vernal. The effect of competition on the legume becomes increasingly pronounced as drainage conditions of the soil become less favorable and to some extent, as the cutting intensity is increased.

Progeny evaluation of clones from the second cycle of selection is in progress for both timothy and orchardgrass. The clonal characteristics of these selections would appear to indicate that cyclic selection is of considerable value in these species. Color, disease resistance and average upright growth habit resistant to lodging are the principal characteristics of interest in each of the maturity classes of timothy. These same characteristics and greater seed potential are important in late orchardgrass.

Information is accumulating on the effect of clone number and seed generation in performance of synthetics of perennial hay grasses. There has been no appreciable yield decline in advanced generations for most synthetics studied. The best synthetics to date have had four or five parent clones; this judgment is based primarily on yield performance. Synthetics with much larger numbers of parent clones have given good yield performance, however. There has been no evidence that the use of a large number of clones results in a wider adaptation range.

Title: LETHAL LEVELS OF NITRATES IN FORAGES

Leaders: R. F. Crawford and W. K. Kennedy

In 1958, four yearling and four pregnant heifers were fed oat hay containing 1.24 percent nitrates for five weeks with no apparent ill effects. The pregnant heifers receiving high-nitrate hay had normal calves. Also, the hemoglobin and methemoglobin contents of blood from animals receiving high-nitrate oat hay were similar to those found in the blood of animals consuming low-nitrate oat hay. Further feeding trials indicated that the accepted lethal level of 1 percent nitrates in forage may be too low, and further studies are in progress to establish the correct lethal level.

Apparently there is little danger of nitrate accumulation being dangerous in commercial strains of orchardgrass with 3 or 4 applications totaling 300 pounds of nitrogen per acre per year. Commercial strains of brome grass, tall fescue, and timothy have been fertilized with as much as 200 pounds of nitrogen per acre per year and no serious nitrate accumulation occurred. The danger of nitrate poisoning of cattle from perennial grass pasture or hay that has been heavily fertilized with nitrogen is not great. But because certain varieties do accumulate more nitrates than others, further investigation is needed before the upper levels of nitrogen fertilization can be established for perennial grasses. Also the effects of prolonged feeding of forage containing sublethal quantities of nitrates (less than 1 percent) have not been determined. Until more information is available on nitrate accumulation in forage crops, amounts of nitrogen fertilizer in excess of 300 pounds of actual nitrogen per acre per year should be used with care.

Title: INFLUENCE OF LACERATION OF ENSILED FORAGE UPON THE QUALITY OF THE
RESULTING SILAGE

Leaders: P. C. Kearney and W. K. Kennedy

Laceration or bruising treatments were imposed on alfalfa-bromegrass mixtures in an effort to determine whether the quality of the resulting silage could be improved. Treatments consisted of: 1) long cut forage, 2) long cut forage with laceration, 3) chopped forage, and 4) chopped forage with laceration. Laceration was achieved with a rotary mower. All samples were high in moisture (82 percent) at time of ensiling. Results showed that no difference in quality, as judged by pH, odor or color, could be attributed to the latter three treatments. The long cut silage, however, was a poorly fermented product, having an undesirable odor and high pH.

Later studies were established to determine the influence of various degrees of air exclusion on the ensilage process. Superimposed on these aeration treatments were laceration and chopping treatments. The pH of lacerated silages declined more rapidly than the pH of chopped silages, reflecting the rapid juice release from the plant cells. Eventually all treatments reached the same pH level and again no differences could be attributed to laceration.

These data suggested that any beneficial effect of laceration would be on wilted rather than unwilted forage. Pure alfalfa was allowed to wilt to 34 percent and 39 percent dry matter and subjected to laceration. Silage fermented in this manner was free from slime and had good color and odor. Chemical analyses showed that the pH dropped only to 5.0, but the silage contained about 5.5 percent lactic acid for the 34 percent D.M. silage and 3.7 percent lactic for the 38 percent D.M. silage. This is a higher lactic acid concentration than is usually observed in chopped wilted silage, but further research is needed in order to separate the effects of laceration per se from its effect upon the exclusion of air from the silage mass.

Title: EFFECT OF MOLYBDENUM UPON THE GROWTH AND DEVELOPMENT OF FORAGE
LEGUMES ON NEW YORK SOILS

Leaders: W. M. Kliever and W. K. Kennedy

Studies previously reported (1957 Annual Report, page 84) have been expanded and a detailed field study was established in the spring of 1958 to compare the response of alfalfa and birdsfoot trefoil to molybdenum applied alone and in combination with different increments of lime. Both legumes respond to applications of molybdenum when the soil pH is less than 6.0, but the relative response is much greater for birdsfoot trefoil than for alfalfa.

While molybdenum is not a complete substitute for an adequate lime program, it appears to be a good enough substitute for lime to warrant its use on birdsfoot trefoil. At the present time it is questionable if a similar recommendation can be made for alfalfa.

Title: EVALUATION OF ANIMAL PRODUCTION UNDER DIFFERENT SYSTEMS OF GRAZING

Leaders: J. T. Reid and M. J. Anderson (Department of Animal Husbandry), and W. K. Kennedy (Department of Agronomy) cooperating

Four systems of grazing management of dairy cows were compared for three years on a uniform mixture of alfalfa, Ladino clover and smooth brome grass. Cows on the 3-paddock rotational system maintained milk production as well or better than cows on the 6-paddock, strip and zero grazing methods of management. Milk production per acre also was as high for the 3-paddock system as for the other methods of management. Larger quantities of excess forage were harvested from the zero grazing system than from the other systems, but it is questionable if the additional forage would offset the decrease in milk production and the increase in harvesting costs.

Final recommendations regarding the advantages and disadvantages of zero and strip grazing are being deferred until more data are available. However, the study does clearly demonstrate the advantages and necessity of heavy stocking rates if milk production per acre is to be used as a criterion for most efficient pasture management. A valid comparison between grazing systems of production per acre cannot be made unless the grazing pressure for all treatments is sufficiently heavy to fully utilize the available forage.

Title: MAXIMUM UTILIZATION OF FORAGES BY LIVESTOCK

Leaders: S. T. Slack, K. L. Turk, G. W. Trimberger, J. I. Miller, J. T. Reid, D. E. Hogue and J. K. Loosli (Department of Animal Husbandry) and W. K. Kennedy and H. A. MacDonald (Department of Agronomy)

Further experiments with lactating cows, dairy calves and yearling dairy heifers in 1958 continue to show marked advantages for early-cut forages. Where continuous feeding designs have been used, differences in milk production amounting to 30 to 40 percent for early-cut hay and/or silage over late-cut hay have been noted. More milk per pound of dry matter intake has been obtained from wilted silage than from barn-dried hay (unheated air) cut on the same day.

Experiments are now in progress to determine the basic reasons for the differences in value between early-cut and late-cut forage and between dry matter in silage and hay.

One feeding trial has been completed in 1958 to compare birdsfoot trefoil hay with a mixture of alfalfa, clover and grasses.

A comprehensive experiment was conducted in 1958 to measure the influence of time of cutting of mixed hays on the rate of gain, feed consumption and final liveweight grade of fattening lambs. Two first cuttings; one early, cut on May 31, 1958; and one later, cut on July 7, 1958; and one second cutting, cut on August 4, 1958 were each fed to groups of 88 lambs. In addition, each hay was fed as either barn-dried or field-cured as a secondary objective of the experiment.

The advantages of the early-cut hay were apparent as the lambs on this treatment gained 0.42 lbs. per day, consumed an average of 2.26 lbs. of hay per day and graded good to choice as compared to 0.26 lbs. gain per day, 1.83 lbs. hay consumed and utility to good grades for the lambs fed late-cut hay. The lambs fed the second cutting hay gained 0.37 lbs. per day, ate 2.10 lbs. of hay per day and graded average to high-good which represents a performance much better than the lambs fed the late-cut hay but not as good as the lambs fed the early-cut hay.

The differences due to method of curing were small and not consistent except for grade. The lambs fed the barn-dried hay consistently graded about one-third of a grade higher than the lambs fed field-cured hay.

Title: DISEASES OF FORAGE CROPS

Leaders: D. A. Roberts and R. E. Ford, J. M. Kainski, L. Lopez-Matos, P. E. Oxelfelt, Evamarie Sander and C. H. Ward (Co-operators: Departments of Plant Breeding, Agronomy and Entomology)

Root rots of birdsfoot trefoil in New York were classified as (1) rots of fibrous roots, (2) rots of the pith, and (3) rots of the cortex. Fusarium oxysporum, F. moniliforme, F. roseum, and F. tricinctum were most often associated with the first 2 categories of root rot, whereas Rhizoctonia solani, Sclerotium bataticola, Phialophora spp., and Fusarium spp. were frequently found in association with cortical rot. Forty-two pathogenic isolates and 2 non-pathogenic ones were selected for further testing on the basis of pathogenicity tests in which plants were grown in nutrient sand culture in glass tumblers (1957 Annual Report, page 77). Fungi non-pathogenic to seedlings in tumblers were also non-pathogenic to 8-month-old and 2.5-year-old plants; many, but not all, fungi pathogenic to seedlings were also pathogenic to the mature plants. Pathogenicity tests conducted with seedlings grown in sand culture were considered as reliable

as those conducted with established plants grown in non-sterilized soil. Tests in which steam sterilized soil was used were least reliable because of early recontamination by 1 or a few species of fungi that quickly became predominant in the soil and occasionally enhanced or suppressed the activity of the pathogen being tested. Although R. solani was highly virulent, it was found only once. S. bataticola was isolated from roots collected in 4 counties of eastern New York. It is concluded that most root rots of birdsfoot trefoil in New York are caused by species of Fusarium. Also, these and saprophytic fungi often adversely affected seed germination, and probably contributed to failures in stand establishment.

Fusarium roseum was proved to be the cause of a leaf and stem blight of birdsfoot trefoil. Diagnostic symptoms were bleaching of foliage near the tops of affected plants and drooping of shoot tips, followed by death of shoots. Optimum temperature for disease development in a saturated atmosphere was about 82° F.

Colletotrichum trifolii was isolated from anthracnose diseased alfalfa plants, and the pathogenicity of the fungus was proved.

Two hundred and twenty-six samples of soil and 1,012 plant samples were collected from 24 counties in New York in 1958. Soil samples were processed in a Seinhorst Elutriator, and root samples were processed by Young's method. Nematodes present in each sample were identified and the numbers present were determined. Plant parasitic nematodes associated with forage crops and present at rates of more than 200 per 250 ml. of soil were species of Helicotylenchus, Meloidogyne, Paratylenchus, Pratylenchus, Heterodera, and Tylenchorhynchus. In some instances, high populations of parasitic nematodes were correlated with poor plant growth and decreased stands. Most severely damaged forage crops were birdsfoot trefoil, alfalfa, and white clover. Less severely damaged crops were red clover, soybean, timothy, orchardgrass, brome grass, and redtop.

For quantitative work, red clover was a better source of red clover vein mosaic virus than were garden pea, broad bean, and globe amaranth. As diluents, cysteine solutions at pH 4 or 5 were superior to cysteine solutions at pH 6, to acetate or M phosphate buffers at pH 4.5, or 6, and to deionized water; water was superior to the 2 buffers. Clarifying inoculum by centrifugation before freezing increased infectivity. Darkening globe amaranth plants for 24 hours before - but not after - inoculation enhanced local lesion production. Infection decreased the rate of apparent photosynthesis in red clover, and increased the rate of respiration up to 9 weeks after inoculation.

Alfalfa mosaic virus was not completely inactivated in shoots of alfalfa plants kept at 95° F. for as long as 14 days or at 113° F. for as long as 6 hours. Shoots were so severely injured by these treatments that tip cuttings could not always be rooted successfully.

Plots of alfalfa were clipped once and/or sprayed twice with captan during the year of seeding. The influence of treatments on stand, disease severity, and yield will be determined in 1959.

Title: ALFALFA SNOUT BEETLE INVESTIGATIONS

Leaders: H. Y. Forsythe, Jr. and George G. Gyrisco

Large acre-size plots were treated in 1957 using 1, 3 or 5 pounds per acre of granulated dieldrin. Seven of the 10 replicates extending from Oswego to Clayton were sampled for grubs in the late fall of 1958. All dosages of dieldrin were found to give good control of the larvae. Treated plots had 3 to 10 times as many plants per unit area as the untreated checks. The average number of grubs in the treated plots was 0.1 per square foot while the untreated checks averaged 2.2 grubs per square foot.

In a small plot size experiment near Clayton treated in 1956, granulated dieldrin at 3 or 5 pounds per acre and granulated heptachlor at 5 pounds was still giving excellent control of the larvae but heptachlor at 3 pounds per acre and aldrin at 3 or 5 pounds were found to be less satisfactory.

Title: CLOVER ROOT CURCULIO INVESTIGATIONS

Leaders: H. Y. Forsythe, Jr. and George G. Gyrisco

In a survey of seedlings of alfalfa and red clover, Sitona hispidula was more common than S. flavescens. The latter was not found in 9 of the fields surveyed.

Under laboratory conditions, Sitona females showed no preferences for oviposition sites. Most of the eggs were scattered on the soil surface.

Field collected females laid 0.1 to 20.1 eggs per female per day. One female which lived for 3 months laid a total of 1911 eggs.

Eggs were found to hatch in 9.1 days at a constant temperature of 86° F. and 31.5 days at a constant temperature of 59° F. Eggs maintained at 50° F. for 2 months failed to hatch but when then placed at 77° F. hatched in 2.6 days.

Pupal period ranged from 10.0 days at 86° F. to 17.5 days at 66° F. In the field most pupae were found at a 2-inch depth.

Title: POTATO LEAFHOPPER AND PEA APHID INVESTIGATIONS

Leaders: H. Y. Forsythe, Jr. and George G. Gyrisco

Net sweeps taken at hourly intervals during a 24-hour period for several days indicated that the potato leafhopper is most active in early evening while the six-spotted leafhopper was most active late at night. The pea aphid was more active during the daylight hours than at night.

Methoxychlor at 1.0 pound per acre is still the most effective insecticide for the control of the potato leafhopper. Guthion, Ethion, Thiodan, Trithion at 0.5 and 1.0 pound per acre and Shell 4402 at 1.0 pound showed some promise and warrant further testing.

Thiodan, Trithion and Guthion at 0.5 and 1.0 pound per acre and Shell 4402 at 1.0 pound per acre showed excellent control of the pea aphid up to 7 days after application.

Title: MEADOW SPITTLEBUG

Leaders: George G. Gyrisco and H. H. Shorey

Phosphamidon, Sevin, Ethion, Trithion, Thiodan and lindane were tested for effectiveness for control of the meadow spittlebug. Only Thiodan was found to be as effective as the proved standard, lindane. The logarithmic sprayer was found to be an effective tool for the application of insecticides to be screened for the control of nymphs of the meadow spittlebug.

Title: EUROPEAN CHAFER STUDIES

Leaders: H. H. Shorey and George G. Gyrisco

Both Thiodan and Trithion were very effective against grubs of the European chafer at rates as low as 2 pounds per acre. Sevin gave good control but appears to have little residual activity. After 8 years chlordane at 8 pounds per acre still gave near perfect control while parathion and BHC at the same dosage had lost their effectiveness for grub control.

Bacillus thuringiensis was ineffective for grub control when tried in several limited tests.

Depth of second instar larvae was found to be related to moisture of the soil although the second instar larvae did not migrate downward until after the surface soil had become severely dried. The rate of larval development was found to be proportional to the moisture of the soil, being greatly retarded in very dry soils.

A marked movement of chafer adults from medium (9-12 percent) to low (0-6 percent) soil moisture was found.

Adults congregated in largest numbers in soils with temperatures below 55° F. while second instar grubs left areas of high and low temperatures to congregate in soils with temperatures between 63-80° F. Temperatures of 42.5° C. resulted 50 percent kill of pupae, eggs, adults and first instar larvae in one-half hour.

More eggs are laid in soils in median moisture than those very dry or wet. Eggs were successfully incubated while fully submerged in water.

Title: ALFALFA WEEVIL STUDIES

Leaders: C. S. Koehler, George O. Poinar Jr. and George Gyrisco

Heptachlor at 4 ounces per acre gave excellent control of larvae for 32 days. Chlordane at 32 ounces and lindane or endrin, at 4 ounces gave good larval control for two weeks after treatment while phosphorous containing compounds gave effective control for only about 1 week. Heptachlor at 8 ounces per acre gave good control of the adults for two weeks and was the best insecticide tested for that purpose.

Fifteen counties are now infested with alfalfa weevil in New York.

The peak of alfalfa weevil development occurred in early June. Larval feeding was delayed and much of the injury occurred on the second cutting. Populations declined until mid-August when the lowest number was found. Weevils again increased in numbers in mid-September when many young larvae appeared.

Weevils were found to be most numerous between 1-3:00 A.M. when checked hourly for 24 hours.

In a study of resistance, Ranger and Alfa were found to be superior to DuPuits, Vernal and Narragansett in that order, to alfalfa weevil damage. Narragansett was found to be twice as susceptible as Ranger.

Two new parasites of the alfalfa weevil were found in New York - Spilochalcis albifrons (Walsh) a larval parasite and Mijmar pratensis (Fourest.) an egg parasite. Neither occurred in large numbers.

Title: STUDIES ON THE INSECTS OF BIRDSFOOT TREFOIL

Leaders: R. L. Ridgway and George G. Gyrisco

Dalapon and/or 2,4-D were found to be fully compatible with insecticides, biologically and chemically, for use on birdsfoot trefoil. Good increases in seed were obtained with both of these herbicides in conjunction with the control of the meadow spittlebug.

The use of lindane for spittlebug and Thiodan for plant bugs as a pre-bloom spray gave a 148 percent increase in seed yields and was better than a spittlebug spray or a pre-bloom plant bug spray alone. Two applications of insecticides seemed to be suggested — one for spittlebug and one for plant bugs for best yields of birdsfoot trefoil seed.

PENNSYLVANIA

Title: THE GENETICS AND IMPROVEMENT OF ALFALFA (MEDICAGO SATIVA L.)

Leaders: H. R. Fortmann, R. W. Cleveland and J. L. Starling

Regional Research. Yields were measured for the second year on three broadcast plot trials established under NE-28 in 1956. These included the polycross progeny tests, of which one was made up of progenies of creeping rooted clones, and a variety and synthetic test. First year's results were obtained on a third polycross progeny trial established in 1957. Early years' results from these trials indicate several superior progenies and synthetics are available. These findings are promising for the development of superior new varieties adapted to the Northeast region.

Parental clones were maintained in a spaced plant nursery and were evaluated for reaction to foliar disease.

A second varieties- and synthetics-trial being regionally tested was established at two locations, Centre Hall and Landisville.

Variety Trials. Variety trials established at three locations in 1955 were harvested for the third season. Two others established in 1957 were harvested for the first season. A new trial was established at Centre Hall.

Other. Second year's results were obtained from one location and first year's results from two locations by Mr. R. H. Cole in grass-legume evaluation study. Trials contain three varieties of alfalfa requiring different management for maximum production.

Usefulness of Findings. Certain polycross progenies and synthetics tested under regional project NE-28 are superior to currently used varieties. Synthetic formulations should be possible after one additional harvest year.

Information from variety trials is used as basis for annual variety recommendations. Older trials show superiority of wilt resistant varieties. Adaptability of varieties to particular environmental conditions is being confirmed.

Work Planned for Next Year. Harvest and evaluation will continue on all NE-28 trials established in 1956, 1957 and 1958.

Variety trials at Centre Hall, Ligonier and Troy will be continued. Mr. Cole will collect additional years' data at three locations. Results will be summarized in Ph.D. thesis in 1959. A test will be established at Centre Hall to evaluate performance of controlled variety blends and certain selected commercial blends.

Title: THE GENETICS AND IMPROVEMENT OF BIRDSFOOT TREFOIL (LOTUS
CORNICULATUS L.)

Leaders: H. R. Fortmann, R. W. Cleveland and J. L. Starling

Regional Research. Experiments initiated in 1956 under NE-28 were continued. The trials consist of polycross progenies of Empire and European type clones and varieties and synthetics of both types. Spaced plants of parental clones were also maintained.

Two years' yield results indicate that no clonal performance is significantly superior to the standard varieties available in each type, and little progress is expected from these groups of clones. Several experimental synthetics show some promise, but these likewise are not significantly superior to standard varieties. LC-8, a New York synthetic of European type gave the best performance. Final evaluation of all materials will be made at the end of three harvest years.

Experimental Synthetics. Seed was harvested from four experimental synthetics formulated in 1956. These include two Empire and two European types.

Broadcast plots to test the restricted polycross progeny performance, as well as the components of each synthetic were established. Uniform production of seed remains a major obstacle in the production and testing of synthetics in birdsfoot trefoil.

Out-State Variety Trials. Trials established at five locations in the state were harvested in 1958. Three trials have been harvested for three years. Trials at Ligonier and Centre Hall were harvested for the first year.

Usefulness of Findings. Polycross progeny trials are necessary in evaluation of the merits of any clone for possible use in variety development. Preliminary results of NE-28 trials suggest that slower progress is realized in birdsfoot trefoil through the polycross breeding system than in other major forage species.

The results of variety trials are used in making variety recommendations currently in force. New trials are established as additional varieties are developed.

Work Planned for Next Year. Three out-state variety trials will be harvested in 1959. Two will be discontinued. Third year's yield and characterization data will be collected on all trials established under NE-28. Polycross progeny trials established in 1959 will be harvested for the first time. Currently existing nurseries will be maintained.

Title: THE GENETICS AND IMPROVEMENT OF RED CLOVER

Leaders: H. R. Fortmann, R. W. Cleveland and J. L. Starling

Broadcast plot variety trials at two locations, Centre Hall and Ligonier, were harvested. Red clover demonstration plots at three locations were sampled to provide preliminary data on the relative productivity of the variety, Chesapeake. New variety trials of newer varieties were established at three additional locations in the state.

Work was conducted in selecting plants highly resistant to northern anthracnose from a lot of Wisconsin anthracnose resistant synthetic. Preliminary screening was completed in inoculation chambers. This work in disease resistance is in cooperation with Dr. H. B. Couch. Plants in introduction nursery showing resistance to northern anthracnose have been isolated for use in this work. Plants found to be resistant will be backcrossed to the variety Pennscott with the objective of incorporating their resistance into that variety.

Usefulness of Findings. Variety trial results indicate that the variety Chesapeake is well adapted to Pennsylvania. Although not superior to the currently recommended variety, Pennscott.

Work Planned for Next Year. Variety trials planted in both 1957 and 1958 will be harvested in 1959. After confirmation of resistance of currently selected plants and northern anthracnose, backcrosses to Pennscott will be made.

Title: THE GENETICS AND IMPROVEMENT OF FORAGE GRASSES

Leaders: H. R. Fortmann, R. W. Cleveland, J. L. Starling

Regional Research. Orchardgrass and bromegrass trials established under NE-28 were completed in 1957. Summarization of three years' results from all participating states in the regional tests was completed in 1958 and publications of orchardgrass and bromegrass phases are being prepared.

Bromegrass. Two experimental synthetics were formulated from Pennsylvania data obtained in NE-28 trials. Spaced plant nurseries were established for the production of Syn. 1 seed.

Orchardgrass. Seed was harvested from three experimental synthetics formulated in 1956. Row plantings of Syn. 1 seeds were made for the production of Syn. 2 seed for use in regional trials.

Timothy. Three broadcast plantings were made in May 1958. These consisted of progenies of 22 medium, 22 medium-late and 9 late maturity clones and check varieties.

A spaced plant nursery of these parental clones was established principally for critical maturity evaluation in Pennsylvania.

Progress of newly released and experimental varieties of orchardgrass. Breeders seed of the Pennlate variety released in December 1957 was harvested from a 300 replication nursery established in 1957. This seed was used for the planting of five acres for the production of foundation seed through contract with Mr. Donald Bower, Route 2, Prosser, Washington. Work was continued with several other experimental synthetics representing various maturity classes. Seed for testing purposes was harvested from each of the synthetics. Restricted polycross progeny trials of clones in these synthetics were established in May. First year yield results of broadcast plots of the synthetics themselves indicated that as presently constituted, none of the synthetics was superior to currently available varieties in their respective maturity groups. Information from polycross trials mentioned above will be used in reformulating of synthetics on elimination of certain limiting clones.

Yield of the polycross progenies of 136 orchardgrass clones selected in 1952, was obtained for the second year. Results from this trial indicate that certain clones in each maturity group included are superior to check varieties. These clones will be selected for regional testing with the objective of developing regionally adapted synthetics in orchardgrass.

Variety Trials. Variety trials including orchardgrass, brome grass, and timothy at three locations were harvested for the third year. Trials including these species at two other locations were harvested for the first year. Three new trials were established with cooperating farmers at three additional locations. Trials were also established at the University Agronomy Farm.

First year's data were collected from trials at Ligonier and Tunkhannock designed to critically evaluate the performance of grass varieties and synthetics when grown in conjunction with several legumes and under various management practices. Second-year results from an identical trial at University Park were obtained. Preliminary results suggest that evaluation of experimental varieties by this technique affords additional information on potential of experimental varieties not available when tested in pure stands and uniformly managed trials. This work is under the supervision of Mr. R. H. Cole.

Studies of Hardinggrass and reed canarygrass hybrid. Cytogenetic studies of the F_1 hybrid, the doubled amphiploid derivative and the parental species were completed by J. L. Starling. This work was summarized in a Ph.D. thesis completed in 1958. Backcross of the hybrid to Hardinggrass and F_2 seed was obtained. Seed was also obtained from the doubled derivative. Observations of field plantings indicate that the hybrid has the winter tolerance of the hardy parent, reed canarygrass. Forage qualities are similar to Hardinggrass. Cytogenetic studies of these later generations and backcrosses are being conducted by Mr. D. C. Allison and will be continued under Project 1363, initiated in 1958.

Usefulness of Findings. Preliminary analysis of results in the orchardgrass and brome grass phase of regional tests indicates that the identification of clones which will give superior performance in several states is possible. Isolation of such material should lead to the development of new varieties with a wide region of adaptation.

State variety trial results indicate that Pennlate, the newly released late orchardgrass variety, continues to perform well in the third harvest year. These trials are also the basis of variety recommendation for the state. New trials are necessary as often as new varieties are released which may be important to Pennsylvania.

Work with Phalaris interspecific hybrids indicates that fertile hybrid derivatives with desirable agronomic characteristics may be possible.

Work Planned for Next Year. Yield and other characteristics will be measured on all broadcast plots of polycross progenies of orchardgrass and timothy established in 1956, 1957 and 1958. Syn. 2 seed will be harvested from three orchardgrass synthetics formulated under NE-28. Syn. 1 seed will be harvested from two brome grass synthetics. Regional reports will be prepared on the orchardgrass and brome grass phase of NE-28.

Only one 1955 variety trial (Troy) will be maintained. Trials established in 1957 and 1958 will be continued. Mr. Cole will continue his experiment as described above. Cytological phase of Phalaris work will be continued under project 1363 by Mr. Allison. Field observations and selections of progenies will continue under this project.

Title: CYTOGENETICS OF FORAGE CROP SPECIES AND INTERSPECIFIC HYBRIDS

Leaders: J. L. Starling and R. W. Cleveland

Work under this project in the first months of its initial year has been conducted by Mr. D. C. Allison as a part of his thesis research. The first backcross and the F₂ generation of the hybrid Phalaris arundinacea x P. tuberosa have been produced. Plants are now being grown for meiotic study and for production of subsequent generations. The chromosome number of parental species has been doubled for study of such treatment on crossability. The F₂ generation of the doubled hybrid derivative is also being grown for meiotic study.

The meiotic studies proposed above will be made. An effort will be made to obtain seed of all diploid species of Phalaris for interspecific hybridization. A search will be made for haploid plants in three Phalaris species and in Dactylis glomerata. The cytogenetics of any haploids found will be studied.

The nature of pairing in doubled diploid species of Phalaris will also be investigated.

Title: THE INTRODUCTION AND EVALUATION OF FORAGE CROPS BREEDING STOCKS

Leaders: R. W. Cleveland and J. L. Starling

A second nursery of introduced stocks was established at the Agronomy Research Farm, Centre Hall. Plantings were principally of stocks which had received preliminary evaluation at the Regional Plant Introduction Station, Geneva, New York. Several additional strains were obtained from other agencies of USDA. Entries in nursery are non-replicated but check varieties of each species are provided at close intervals.

The 1958 nursery contains the following accessions:

<u>Species</u>	<u>Number of Accessions</u>
<u>Arrhenatherum elatius</u>	9
<u>Bromus inermis</u>	7
<u>Dactylis species</u>	32
<u>Festuca species</u>	11
<u>Lolium species</u>	7
<u>Lotus corniculatus</u>	15
<u>Lotus species</u>	2
<u>Medicago falcata</u>	4
<u>Medicago sativa</u>	27
<u>Phalaris species</u>	12
<u>Phleum pratense</u>	14
<u>Trifolium ambiguum</u>	2
<u>Trifolium pratense</u>	18
<u>Trifolium repens</u>	16

Introduction nursery planted in 1957 was maintained. Notes were taken on all entries for survival, disease reaction and general desirability.

Evaluation of all stocks to date is preliminary. Red clover strains exhibiting marked resistance to northern anthracnose were identified. These strains will be used in a breeding program.

New accessions by R.P.I.S., Geneva and by other agencies will be obtained in 1959, and a third nursery will be established. The nurseries currently established will be re-evaluated for identification of any superior strains on isolation of genetic source materials.

Title: DETERMINATION OF SEED QUALITY AND VARIETAL PURITY AND IDENTITY OF SEEDS OF IMPROVED STRAINS OF ALFALFA, RED CLOVER, BIRDSFOOT TREFOIL, AND ORCHARDGRASS

Leaders: R. W. Cleveland and J. L. Starling

Two field plantings of a single experiment were established at two locations in Pennsylvania, Centre Hall and Landisville. The former was planted in May and the latter in August 1958. Satisfactory establishment was accomplished at both locations. The experiment was that which was uniformly distributed to stations cooperating in NEM-22, and was designed such that differences among seed lots of varieties of alfalfa, red clover and birdsfoot trefoil could be detected and studied. No evaluations were possible in 1958.

A similar experiment established at the same locations in the previous year, 1957, failed due to winter injury in 1958. No evaluations were possible in 1958, and the plantings were abandoned.

Field plantings of new experiments will be established at one location in Pennsylvania in 1959. The experiments will be designed to measure the extent and type of variability within varieties of alfalfa. Differential cutting treatments will be applied in one experiment.

Field plantings established in 1958 will be evaluated in 1959.

Title: RENOVATION OF UNPRODUCTIVE PASTURES

Leaders: J. B. Washko and J. K. Pasto

Forage yields were taken for the sixth year on this experiment at State College and for the fifth year in Potter County. Birdsfoot trefoil stands are persisting remarkably well at both locations. In 1958 Viking birdsfoot trefoil under grazing management in association with each of the following tall-growing grasses, orchard, smooth brome, timothy and reed canary averaged 2.7 tons per acre; Empire trefoil and Ladino clover with the same grasses averaged 2.3 and 1.7 tons of dried forage per acre, respectively. Under hay management Viking trefoil-timothy, Empire trefoil-timothy and Ladino clover-orchard averaged 3.5, 3.7 and 2.2 tons of forage per acre.

In Potter County after 5 years of grazing the following yields were obtained in 1958; renovated pasture with Empire trefoil-timothy 3.6 tons of dried forage per acre, renovated and seeded to Ladino clover-orchardgrass 1.4 tons and the unrenovated check .6 tons per acre.

The 1958 results further emphasize the high forage yields that can be obtained with pasture renovation and seeding to a long-lived legume such as birdsfoot trefoil in grass associations. One of the reasons farmers have shied away from pasture renovation is the high cost of this practice. If the cost can be amortized over a longer period with resultant lowered cost per year, more interest will be shown in this valuable improvement practice for pastures.

Work will be continued.

Title: PRODUCTIVITY AND LONGEVITY OF RENOVATED PASTURES

Leaders: J. B. Washko and J. K. Pasto

During 1958, investigations on the feasibility of stockpiling forages were continued. The term "stockpiling" refers to the practice of allowing forage to accumulate in the field until needed for grazing. This practice has been suggested as a way of alleviating mid-summer pasture shortages.

The stockpiling experiments were conducted at three locations on the University farm. Birdsfoot trefoil with timothy and Ladino clover with mixed grasses were evaluated at two locations under the following systems of management: (1) Grazing in rotation 3 times at pasture stage (8 inches to 10 inches high), (2) stockpiled until June 15 then grazed, (3) stockpiled until July 1 then grazed, (4) stockpiled until July 15 then grazed, (5) stockpiled until August 1 then grazed, (6) stockpiled until August 15 then grazed.

Measurements of yield, forage consumed by cattle and percentage of T.D.N. in forage were made under each system. Dairy cows were used for grazing at one location and beef cows at the other.

The greatest total yields resulted from the birdsfoot-trefoil-timothy associations stockpiled until June 15 and July 1. The greatest consumption of forage by cattle resulted from rotational grazing and stockpiling until June 15 and July 1. The highest percentage of T.D.N. in forage (70 percent) was produced by birdsfoot trefoil-timothy forage rotationally grazed. Later dates of stockpiling produced progressively lower T.D.N. percentages with forage stockpiled until August 15 having only 50 percent T.D.N.

In the third experiment the influence of four management treatments was studied on stockpiled forage with the following results:

1. Spraying with molasses before grazing materially increased the consumption of low quality forage.
2. A mid-May clipping treatment to delay the maturity of forage increased the quality and rate of consumption of forage but reduced the total yield.
3. Spraying the forage with urea solution before grazing and mowing and windrowing forage before grazing had no significant effect on the amount of forage consumed.

Two years' data indicate that swards containing a high percentage of grass cannot be successfully stockpiled beyond the early head stage of the grass component. However, the experiments to date indicate the possibility of stockpiling swards that contain pure stands of birdsfoot to as late as July 15 with a high level of utilization by cattle.

Birdsfoot trefoil will be seeded in pure stands in order to evaluate the practice of stockpiling 100 percent trefoil swards.

Title: EVALUATION OF GRASSES AND LEGUMES FOR HAY, GRASS SILAGE, AND PASTURE FOR DAIRY COWS

Leaders: P. S. Williams, J. B. Washko and A. L. Haskins

Piper Sudangrass was seeded and subjected to grazing under three levels of nitrogen fertilization (ureaform) 50 lbs., 200 lbs. plowed down, and 200 lbs. applied in split applications of 50 lbs. prior to seeding and a like amount after each grazing. In addition, 500 lbs. per acre of 0-20-20 fertilizer were applied before seeding.

As would be expected the amount of forage produced was related to the amount of nitrogen applied. Four rotational grazings were obtained with 200 lbs. N applications in contrast to three for the 50 lb. rate. There was no advantage in splitting the applications of nitrogen as compared with applying all of it at one time either from the standpoint of yield or feeding value of the forage. The TDN content of the forage fertilized with 200 lbs. of N per acre was higher than obtained with the 50 lb. rate. This was also true for the crude protein content of the forage. Protein content of forage ranged from 21.2 percent to 24.0 percent for the 200 lb. rate and only 16.6 percent to 18.5% for the 50 lb. rate.

Sudangrass is becoming an important summer grazing crop in the state. High fertilization rates with emphasis on nitrogen are necessary for maximum production. These results indicate no advantage in splitting the nitrogen applications over putting all the N on at once. If periodic top-dressing of N can be eliminated this will result in lowering the cost of producing pasturage from Sudan in that it will save on labor and equipment. This high rate of nitrogen fertilizer did not cause any digestive disturbances to the livestock grazing same even when grazed after a killing frost.

This project is in the process of being revised and a publication written to cover the completed work. Plans are being made to repeat the work with summer annuals in 1959 under the revised project.

Title: THE NUTRITIVE VALUE OF GRASS SILAGE AS AFFECTED BY SPECIES AND STAGE OF MATURITY

Leaders: R. W. Swift, J. W. Bratzler, T. A. Long, E. Keck and J. B. Washko

Black amber sorghum, Pa. 602 hybrid and Dwarf 602 hybrid corns were grown with and without soybeans for silage purposes in 38-inch rows. The experimental site was fertilized with 500 lbs. per acre of 0-20-20 prior to seeding. In addition 100 lbs. of nitrogen per acre were applied when the sorghum and corns were grown alone and 50 lbs. in soybean mixtures.

The sorghum produced less forage with soybeans than when grown alone. The reverse was true for the two hybrid corns. More forage for silage was produced by both hybrid corn varieties than with the sorghum. Plant composition of Pa. 602 hybrid and Dwarf 602 hybrid was also compared according to plant parts. The results are best summarized in the following table:

<u>Hybrid</u>	<u>Stalks</u>	<u>Leaves</u>	<u>Husks</u>	<u>Ears</u>
Dwarf 602	22.8	23.8	20.0	33.4
Pa. 602	30.3	17.4	10.4	41.8

As would be expected the dwarf hybrid had less stalk, more leaves and more husks but less ear weight than regular corn. Whether this will be reflected in feeding value remains to be seen upon completion of the feeding trials.

If dwarf corn has a higher feeding value than regular hybrid corn or sorghum, it may well replace part of the acreage devoted to these crops. It has several advantages over regular corn. Its shortness makes it less susceptible to lodging, it is easier to harvest and its high leaf to stalk ratio makes a leafier silage.

Soybeans are difficult to plant when included with corn or sorghum to raise the protein level of the resulting feed. If nitrogen fertilizer can be used to increase protein content of corn or sorghum rather than soybeans, several difficult management problems in handling these crops will have been removed.

Hybrid sorghum will replace the open-pollinated variety and the soybeans may be omitted depending upon the outcome of the silage feeding trials.

Title: SEEDING AND ESTABLISHMENT OF GRASSLANDS

Leader: J. B. Washko

Spring seedings of alfalfa-bromegrass, Ladino clover-orchardgrass, and birds-foot trefoil-timothy were made in winter barley, winter wheat, spring oats, and on a prepared seedbed without a companion crop with four implements incorporating the following methods in 1958: (1) Band-seeding in 8-inch rows with press wheels, (2) band-seeding in 7-inch rows, (3) band-seeding in 10-inch rows, (4) broadcast seeding with cultipacking, (5) broadcast seeding from power take-off of tractor, (6) same as (5) but with soil crust broken with weeder, and (7) broadcast seeding on frozen soil. Yield data were obtained on the seeding made in 1957 and seedling counts were made on seedings made in 1958.

Yields of alfalfa-bromegrass were the same whether band-seeded or broadcast-seeded with the various implements on a prepared seedbed and when seeded with a spring oat companion crop. However, under more difficult conditions such as seeding in established small grains, band seeding was superior to broadcast seeding. Similar results were obtained for a birdsfoot trefoil-timothy mixture except that for this association band seeding was superior to broadcast even when seedings were made in a spring oat companion crop. The Ladino clover-orchardgrass association was generally favored by broadcast rather than band seeding.

Differences in forage yields due to seeding implements were not great. A bandseeder with row spacings of 20 inches was inferior to similar machines seeding in 7, 8, or 10 inch rows for the alfalfa-brome and birdsfoot trefoil-timothy mixtures but not for the Ladino clover orchardgrass. Broadcast seeders except for the wheelbarrow seeder were inferior to all band seeders for the birdsfoot trefoil-timothy association; the poorest being the broadcast seeder operating from the power take-off of a tractor.

Seedling counts on the 1958 seeding were quite variable and did not appear to be related to seeding methods or implements.

Results of this experiment indicate that precision seeding methods are of greater value under difficult conditions than under good conditions of seeding. With the use of precision equipment farmers can obtain better stands of forage crops with less seed. Since successful stands will be possible with less seed they will be able to save on seeding costs per acre and also minimize seeding failures. Yields will be taken on seedings made in 1958.

Title: FORAGE AND GRAIN PRODUCTION OF WINTER SMALL GRAINS AS INFLUENCED BY FERTILIZATION AND MANAGEMENT PRACTICES

Leaders: J. B. Washko and A. L. Haskins

Piper Sudangrass and Pearl millet were seeded for rotational grazing with different amounts of fertilizer applied with the seed and prior to seeding to determine the influence of fertilizer placement on forage productivity. The following amounts and ratios of fertilizers were applied: 300 lbs. with the seed, 500 lbs. of a 5-10-10 with the seed and prior to seeding, and 500 lbs. of a 10-10-10 with the seed and prior to seedings.

The millet stands were so poor due to a combination of wet cold weather and fertilizer injury to seed that the plots seeded to this species were abandoned. The danger of applying rates of a complete fertilizer in the range of 500 lbs. per acre in contact with the seed of the large summer annuals was emphasized despite the very favorable soil moisture conditions prevalent in 1958. Where 500 lbs. per acre of a 5-10-10 fertilizer were

applied with the seed, Piper Sudangrass yielded 2.08 tons per acre, whereas if the same was applied prior to seeding and disked into the soil, yields averaged 2.40 tons per acre. When 500 lbs. of 10-10-10 fertilizer were applied with the seed, yields averaged 2.19 tons, whereas if applied prior to seeding, yields averaged 2.77 tons of forage per acre.

Injury was greatest at the time of the first grazing. By the time of the second grazing very little fertilizer injury was apparent with the 500 lbs. of the 5-10-10. However, where 500 lbs. of a 10-10-10 were applied, injury persisted into the second grazing. Injury was due primarily to reduction in plant numbers.

For high forage yields heavy fertilization rates are recommended for Sudan-grass and millet. These results indicate that high forage yields are dependent upon adequate fertilization of nitrogenous fertilizers but that placement of this fertilizer is highly important. To minimize danger of fertilizer injury this fertilizer should be worked into the seedbed prior to seeding. Thus rather than increase forage yields fertilizer may reduce yields with improper placement with respect to the seed.

Work on this project has been completed and it is to be revised in 1959.

Title: AN INVESTIGATION OF ALFALFA CROWN ROT

Leaders: H. B. Couch, H. R. Fortmann, J. L. Starling and R. W. Cleveland

Inoculation experiments were conducted on Grimm alfalfa in greenhouse experiments with Fusarium roseum, F. oxysporum, and Rhizoctonia solani singly, and each species in combinations with the nematode species, Paratylenchus nanus.

Plant inoculated with R. solani developed a crown bud rot condition, while F. roseum and F. oxysporum incited crown and root cortical rots.

Severity of disease was accentuated considerably when P. nanus was combined with R. solani. Combination of nematode with the other two species of fungi, however, did not increase disease severity.

Title: DISEASES OF RED CLOVER

Leader: H. B. Couch

The cultural variability of Kabatielle caulivora was studied. A combination continuous, and/or intermittent flow nutrient replenishment apparatus was designed. Using the continuous nutrient replenishment technique, it was found that K. caulivora could be held in its initial budding, yeast-like

stage of growth indefinitely. In addition, it was established that a concentration of 300×10^4 conidia per ml. was required in order for mutation from the conidial to the mycelial growth form to occur.

Working with Seitz filtrates of cultures containing 300×10^4 conidia per ml., and above, a 24-hour exposure of yeast-like conidia to the filtrate was sufficient to cause mutation to the mycelial type at spore concentrations of 50×10^4 per ml., and less.

When Seitz filtrates of cultures containing 300×10^4 conidia per ml. were autoclaved for 5 minutes at 120°C ., their mutagenic capabilities were inactivated.

On the basis of the work to date, it is concluded that initiation of the mycelial growth form of K. caulivora in culture is due to a non-heat stable auto-metabolite.

Title: FORAGE INSECTS

Leader: Norris D. Blackburn

The alfalfa weevil continued to be the major forage insect pest in Pennsylvania during 1958. It is now known to be present in almost two-thirds of the counties of the State. Significant foliage injury has been observed to occur approximately 2 years after the insect is first noted in a new area.

Data on the biology of the weevil indicated that egg deposition and subsequent egg development were prolonged by unfavorable temperatures during the spring of 1958. As a result, larvae of various ages were present in untreated fields for a considerable period after the usual time of harvest of the first crop. During such seasons it is extremely difficult, if not impossible, to predict in advance the precise point in larval population development when materials should be applied in order for a single treatment to provide adequate plant protection until the first crop is harvested.

Control experiments were designed to compare the relative effectiveness of granulated formulations and emulsifiable concentrates applied at equivalent rates in early-season treatments before the adult insects became active. Granulated and emulsifiable formulations of heptachlor were each applied at rates of 0.5, 0.75, 1.0 and 1.5 pounds (actual) per acre at about the 3-inch stage in plant development.

Although the two lowest application rates of heptachlor did not provide adequate protection in these early-season treatments, no significant difference in effect on subsequent larval population levels could be noted between the two formulations regardless of the rate of application employed in these experiments. When applied at the rate of 1.0 pound /acre,

the reduction in larval population levels was 94 percent and 95 percent for the granulated and emulsifiable formulations, respectively. When both formulations were applied at the rate of 1.5 pounds/acre, an almost identical reduction of approximately 95 percent was obtained in each case.

Early-season treatments, before the adult insects become active, require higher application rates than those later in the season which are directed solely against the larval population. However, all data indicate that additional treatments are not required when adequate amounts of the appropriate insecticide are applied in the spring during the early stages of plant development.

RHODE ISLAND

Title: NITROGEN FERTILIZERS FOR GRASS AND GRASS-LEGUME FORAGE MIXTURES

Leaders: R. C. Wakefield, J. W. Cobble and J. B. Smith

Plots of S-37 orchardgrass and Lincoln brome grass were fertilized with two sources of nitrogen (inorganic and organic) at three times and three rates of application for the second year (1957 Annual Report, page 96).

Applications of 50 and 300 pounds of N per acre resulted in average yields of 1.65 tons and 2.61 tons of dry matter per acre over the check plots. Dividing nitrogen into 3 applications was superior to a large single application in the spring during the wet 1958 season.

Orchardgrass gave a greater yield response than brome grass at all harvests to equivalent applications of nitrogen. Ladino clover was lost from mixture plots during the dry summer of 1957 but yields of grass were higher from these plots during 1958 due to the greater N reserve in the soil. Ammonium nitrate was again superior to ureaform in dry matter production.

In grazing trials, nitrogen-fertilized orchardgrass resulted in greater yields and animal intake but lower weight gains with dairy heifers than orchardgrass-Ladino clover.

Title: FORAGE CROP ESTABLISHMENT STUDIES

Leaders: R. C. Wakefield and R. J. Hull

Yield data from the 1957 herbicide experiment (1957 Annual Report, page 97) conducted under heavy broadleaved and grass-weed competition revealed that the combined use of 4(2,4-DB) plus dalapon at the seedling stage resulted in superior yields of alfalfa, birdsfoot trefoil and Ladino clover during the second season (1958). Data from hand-weeded check plots revealed that grass weeds had a more pronounced effect than broadleaf weeds on legume seedling establishment and subsequent yields. Grass weeds became a serious inhibiting factor to legume establishment when broadleaved weeds were controlled.

During 1958, pre- and post-emergence herbicides applied alone and in combinations were evaluated on spring seedings of alfalfa and birdsfoot trefoil under conditions of heavy broadleaved and grass-weed competition. The pre-emergence materials Neburon and EPTC were promising and the post-emergence use of 4(2,4-DB) plus dalapon again gave good results. DNBP and MCPA applied alone with dalapon were not satisfactory because of ineffective broadleaved weed control and/or injury to legumes.

Title: BREEDING AND EVALUATING ALFALFA FOR EASTERN UNITED STATES

Leaders: T. E. Odland and R. C. Wakefield

The breeder seed plot of Narragansett alfalfa is being maintained. About 500 new cuttings from the parent plants were made and added to the new seed plot. The original planting made in 1946 was discontinued after obtaining 11 seed harvests. The 1958 season was extremely wet and the seed set was poor. Only about 6 pounds of usable breeder seed was obtained.

Title: INSECT AND ALLIED PESTS OF FORAGE CROPS AND THEIR CONTROL UNDER RHODE ISLAND CONDITIONS

Leader: T. W. Kerr, Jr.

Data are being obtained on the seasonal occurrence and relative numbers of insects, particularly leafhoppers, on timothy, brome grass, and orchard grass in order to most effectively time the application of insecticides and avoid residues.

Title: BIOLOGY AND CONTROL OF NEMATODES ASSOCIATED WITH PLANT DISEASES
INJURING FORAGE CROPS

Leader: G. J. Stessel

Alfalfa fields have been sampled and the nematode community identified. Nematocide-treated plots planted to alfalfa are being observed for comparative growth and persistence. Greenhouse studies of the relation of various nematodes to the alfalfa plant are in progress, particularly when Fusarium spp. are present.

Title: PESTICIDE RESIDUES IN RELATION TO FORAGE CROP PRODUCTION

Leaders: T. W. Kerr, Jr. and C. E. Olney

Measures are under study to degrade DDT residues in sweet corn silage. Valid sampling procedures (e.g. size and number of plots) for determining insecticide residues on alfalfa are being investigated.

Title: CONTROL OF DISEASES OF FORAGE CROPS

Leaders: F. L. Howard, C. Roberti and T. C. Poland

The interdependence of physical and biological environmental factors on the initiation of the crown-root rot complex in alfalfa is being studied. The role of freezing injury on infection courts for Fusarium spp. is the subject of experimentation. Chemicals exhibiting specific toxicity for Fusarium spp. are being examined.

Title: INVESTIGATION OF THE ALFALFA "DWARF" VIRUS IN RHODE ISLAND

Leaders: W. N. Stoner and Richard F. Stouffer

The biology and ecology of the vectors, hosts, and viruses are being studied to determine if known control methods can be applied. Transmission studies are in progress to permit the development of definitive symptoms.

VERMONT

Title: FORAGE CROP INSECTS, THEIR RELATIVE IMPORTANCE AND CONTROL

Leader: George B. MacCollom

Evaluation of insecticides for control of the insect complex affecting birdsfoot trefoil seed production was continued in 1958. (1957 Annual Report, page 99). Sevin at 2 lbs. actual per acre and Guthion at 1 lb. actual per acre were as effective as Toxaphene at 1.5 lbs. actual or Endrin at 0.2 lbs. actual per acre.

1958 results indicate that proper timing of applications is essential for optimum results. Variation in application dates of 7 days resulted in significant differences. Correlation of optimum yields and insect development for 1956, 1957, and 1958 indicates that insecticide applications can be accurately timed by degree days.

Title: CHANGES IN PRODUCTION AND STAND AS AFFECTED BY DIFFERENT SEEDING MIXTURES OF DIPLOID AND POLYPLOID LADINO CLOVER

Leader: T. R. Flanagan

Two years' yield results from seeding equivalent numbers of pure line seed of a commercial lot of Ladino clover and seed from an advanced generation of a Vermont polyploid Ladino have shown that increases in the seeding rate have resulted in increased yields of forage, independent of the type of seed used.

Fifty-fifty mixtures of diploid and polyploid seed sown at either the 1 pound, 1-1/2 pound, or 2 pound rates yielded the same amount of forage as pure stands of the diploid sown at the same rates. Pure stands of the ranker growing polyploid were slightly less.

Title: AGRONOMIC EVALUATION OF NEW EXPERIMENTAL LINES AND HYBRIDS OF
BIRDSFOOT TREFOIL

Leaders: T. R. Flanagan and F. Laing

(A) Observations and seed increase were made on 21 hybrid trefoil entries, space planted with 30 ramets of each clone plus additional rows of seed established from the maternal lines involved. Several generations and original F-1 clones of these hybrids of L. corniculatus and polyploid L. tenuis are represented.

Seedling lines were found to be leafier than the plants established from cuttings. Procumbent lines had many branches arising from one main stem while their seedlings had many finer stems with fewer branches per stem. Seedling lines derived from maternal clones with an extended or late bloom period blossomed earlier than their respective maternal lines.

These evaluations represent the fifth cycle of selection in most cases and seed from the superior maternal lines will be evaluated for yield, persistence and disease resistance in polycross progeny plot tests in 1959.

(B) Selections from the 1957 4X L. tenuis polycross nursery plus additional superior plants, plus selected superior polycross seed were established in a new nursery located on heavy soil. Present lines are under the seventh cycle of selection. New genotypes represent the C₁, C₃ and C₄ levels. Some seed is available for limited regional testing.

Title: CONSUMPTION AND UTILIZATION OF FORAGE BY CHICKENS

Leaders: G. M. Wood and R. T. Smith

Studies comparing range and confinement reared pullets were continued in 1958 (1957 Annual Report, page 100). The experiment conducted in 1957 was repeated using White Leghorn pullets instead of those of the White Rock breed as used in 1957. Leghorns appeared to be poorer foragers than the White Rocks. A higher consumption of clover was not obtained during 1958. An analysis of the data is in progress.

Title: THE USE OF BIRDSFOOT TREFOIL MEAL AS A CONSTITUENT OF POULTRY RATIONS

Leaders: G. M. Wood and R. T. Smith

Further feeding trials (1957 Annual Report, page 99) were carried out using two levels each of alfalfa and trefoil dehydrated meals. At the higher level of trefoil meal feeding, growth was significantly depressed. The lower level of trefoil meal feeding produced results equivalent to the control (no meal). Both alfalfa levels depressed the growth of the birds in this experiment.

Title: EFFECT OF SIMULATED PASTURE MANAGEMENT PRACTICES ON THE PERSISTENCE, QUALITY, AND YIELD OF SEVERAL BIRDSFOOT TREFOIL SPECIES AND VARIETIES

Leaders: G. M. Wood and K. E. Varney

Two-year average data (1957 Annual Report, page 98) for this experiment have revealed no significant interaction between variety and years or variety and treatment. Highly significant varietal differences were found however. Viking, Mansfield, and a hybrid, polyploid narrowleaf x Empire, were significantly higher yielding than the other strains but did not differ from each other. Oregon narrowleaf was significantly lower yielding than Empire. Of particular notice was the much better performance of the polyploid narrowleaf strain in comparison with the diploid narrowleaf.

WEST VIRGINIA

Title: NITROGEN ON BLUEGRASS

Leaders: G. G. Pohlman and E. M. Jencks

Studies of time and rate of nitrogen fertilization on bluegrass were continued in 1958. The season with abundant rainfall and cooler than normal temperatures was generally very favorable for grass. The yields of dry grass are given in the following table:

Rate of Nitrogen	Time of Application			
	<u>April 2</u>	<u>June 11</u>	<u>Aug. 18</u>	<u>April 2 & June 11</u>
60	4336	4239	4046	
120	4591	4654	4172	4886
240	5652	5350	4558	5695
360	5848	5831	4424	
480				6287
720				6330

Yield of plot without nitrogen - 3757

Twelve cuttings with a lawn mower were made at intervals of 7 to 22 days.

In all instances production increased following the application of nitrogen. The highest production for the June application was during the month of July. The August application increased September yields to almost the same level as April untreated.

Title: GRASS TETANY

Leaders: D. J. Horvath and N. M. Baughman

A survey (utilizing questionnaires sent to County Agents and Veterinarians) has been made to assess the incidence of so-called grass tetany in West Virginia.

Chemical analyses of forages from farms reporting appreciable trouble have been completed. These analyses show calcium contents lower than averages reported elsewhere for similar forage.

Supplemental magnesium sulfate and bonemeal mixed with ground corn-cob meal molasses feed has been effective in reducing incidence of grass tetany. In a trial now in progress magnesium sulfate is being sprinkled on silage two times daily. Blood magnesium and calcium are being determined in both trials.

Cattle at the Animal Husbandry Farm of West Virginia University refuse supplement containing magnesium, once grass becomes flush.

Title: THE CONTROL OF ROOT AND CROWN ROTS OF FORAGE LEGUMES

Leader: E. S. Elliott

Studies during two seasons indicate that it is not economically feasible in this region to control crown rot (Sclerotinia) on red clover and alfalfa with pentachloronitrobenzene (PCNB).

Title: DISEASES OF FORAGE GRASSES

Leader: E. S. Elliott

A paper, "A report on grass diseases observed in West Virginia" will appear in the April, 1959, Plant Disease Reporter. Another paper will soon be published concerning the damage caused by diseases during the entire growing season on certain forage grasses.

Title: CEREAL AND FORAGE CROP PESTS

Leader: C. K. Dorsey

This study deals with insects affecting forage crops. The most important results to date consist in demonstrating good control of the alfalfa weevil with granular insecticides as reported in West Virginia Agricultural Experiment Station Circular 104.

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